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THE RELATIONSHIP BETWEEN EPISTEMIC BELIEFS AND
KNOWLEDGE CONTRIBUTION
TO ONLINE COMMUNITIES OF PRACTICE

BY

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DISSERTATION

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Abstract

Epistemic beliefs refer to individual beliefs about the nature of knowledge and knowing. The purpose of this study was to explore the relationship between individuals' levels of expertise, epistemic beliefs, and their contributions to an online community of practice. The studied community was hosted by a firm and consisted of members in the design professions. Community members ($N = 315$) completed a self-reported survey via the Internet. Findings supported a four-factor structure of design-focused epistemic beliefs, including Consistency of Design Knowledge, Source Authority of Design Knowledge, Attainability of Design Knowledge, and Contextual Factuality of Design Knowledge. However, the last two factors had low internal consistency. Limitations of and implications for the use of the epistemic belief questionnaire are further discussed. Results indicated that individuals' epistemic beliefs could be used to explain self-reported likelihood of sharing different levels of contributions, as well as the quality and quantity of individuals' actual contributions. Individuals with weaker beliefs in Consistency of Design Knowledge were more likely to post comments when they found a typo, disagreed with information published on a help page, found relevant tips, or wanted to share tutorials they had created. The interaction between Consistency of Design Knowledge and levels of expertise were significantly associated with the self-reported likelihood of sharing low-level contributions and quality and quantity of actual contributions. Findings are discussed with regard to their implications for both theories and designs of online communities of practice.

To Dad and Mom

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Chapter 1

Introduction

An online community or virtual community refers to an aggregation of people who have a common interest, belief, activity, or goal and who interact in a virtual environment (Brint, 2001; Rheingold, 1994). Online communities, similar to physical communities, are distinguished by characteristics such as purposes, technology types, sizes, stages of development, cultures, and governance structures (Blanchard & Markus, 2007; Kim, 2000; Kollock & Smith, 1999; Preece, Maloney-Krichmar, & Abras, 2003). In this study, the discussion of communities focused on online communities of practice (CoPs) hosted by firms, whose purpose was to provide help and create learning communities for their customers. Characteristics of the studied communities are further explained below.

Communities of practice, as coined by Lave and Wenger (1991), describe an activity system that includes groups of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this area by active participation and interaction on an ongoing basis. Less experienced members learn from experts and from interacting with each other. Through active engagement, members mutually negotiate and construct individual and collective meanings, as well as identities, and then gradually create a sense of community. Community members usually share similar experiences, concerns, passions, or the same profession (Wenger, 1998).

Another key characteristic of the special kinds of communities of practice is that community members are firms' customers. The purposes of hosting the communities include building relationships with customers, building brands, getting feedback from customers, supporting product use, and reducing customer service costs by enabling peer-to-peer problem

solving (Moon, 2004; Wiertz & Ruyter, 2007). If organized well, the communities may even influence the way that the firm provides products, so that its customers' needs can be better served (Wenger, McDermott, & Snyder, 2002). With the advancement of information technology and social networking tools, more collaboration and social interaction can take place in virtual space. Many firms, such as Intel, Dell, VMware, and Lonely Planet, have paid attention to this trend and have tried to involve their customers in CoPs that they have created to help customers become more proficient at using their products or services.

The value of online CoPs hosted by firms is dependent upon the community content and experts in the communities (Wenger, McDermott, & Snyder, 2002). These community materials, such as feature articles, blogs, videos, or discussions and answers to questions, serve as learning content and resources to customers. The learning content may be provided by customers, employees of the firm, or a variety of other partners (Wenger, McDermott, & Snyder, 2002). Unlike those in traditional CoPs, participants in online CoPs hosted by firms are not restricted to activities within the boundary of a firm. These special kinds of communities are communities in an extended knowledge system at the consumer level (Wenger, McDermott, & Snyder, 2002). Through participation in the communities, members can gain access to expertise, be better able to contribute to the community, and gradually move toward full participation in the communities, making these communities a critical mechanism for continuing professional development and informal learning for those in the same profession who utilize the same products and practices.

In the current fast-changing workplace, professionals experience informal on-the-job training nearly everyday. It is common for professionals to use search engines to look for information and related learning content multiple times a day. This phenomenon has increased the importance of online communities of practice hosted by firms, which provide an opportunity

for professionals in the same field to interact with each other and share their experience and knowledge. These communities and the content created within them become a critical mechanism for continuing professional development and informal learning. Given the educational potential, it is essential to explore the learning opportunities within these kinds of communities.

Theoretical Framework

In the online CoPs hosted by firms, epistemic beliefs might be a key factor that influences individual's learning process and behavior. Epistemic beliefs are individual beliefs about the nature of knowledge and knowing (Hofer & Pintrich, 1997). Epistemology is an area of philosophy concerned with the nature of knowledge. The primary question, from a psychological perspective, is how individuals come to know and how the manner of coming to know interacts with the cognitive processes of thinking and reasoning (Hofer & Pintrich, 1997).

Various models have been developed since 1970. Unidimensional models were developed first, including Perry's (1970) scheme of intellectual and ethical development, Belenky, Clinchy, Goldberger, and Tarule's (1986) women's ways of knowing, Baxter Magolda's (1992) epistemological reflection model, King and Kitchener's (1994) reflective judgment model, and Kuhn's (1991) epistemological reasoning model. These models all described personal epistemology in a single dimension on a developmental timeline. Schommer (1990) proposed that personal epistemology might be characterized as a set of beliefs. The beliefs within the set may or may not correlate with each other. For example, an individual's belief about knowledge may be more advanced than his belief about justification for knowing. Following Schommer's work, many researchers have proposed different dimensions to capture

the nature of epistemic beliefs. Further discussion is presented in Chapter 2. This current study was based on the model proposed by Hofer and Pintrich (1997). Their model includes four theorized dimensions: certainty of knowledge, simplicity of knowledge, source of knowledge, and justification of knowledge. Among the four dimensions, certainty and simplicity of knowledge are concerned with the nature of knowledge; source and justification of knowledge are concerned with the nature of knowing. The definition of each dimension is presented in Table 1.

Table 1

Dimensions of Hofer and Pintrich's Model of Epistemic Beliefs

Nature of Knowledge	Nature of Knowing
Certainty of Knowledge: Knowledge is viewed as absolute or contextual.	Source of Knowledge: Knowledge is handed down by external authority or constructed by individuals.
Simplicity of Knowledge: Knowledge is viewed as an accumulation of facts or as highly interrelated concepts.	Justification of Knowledge: Individuals move through a continuum of dualistic beliefs to the multiplistic acceptance of opinions to reasoned justification.

In their study on epistemic beliefs, Hofer and Pintrich (1997) suggested focusing on the contextual nature of epistemic beliefs to investigate CoPs and claimed that when people moved from traditional school settings to CoPs, their epistemic beliefs would be different. In this current study, the contextual nature of epistemic beliefs in CoPs was explored using Wegner's (1998) *social theory of learning* to understand the effects of individuals' levels of expertise and epistemic beliefs on online communities of practice hosted by firms. Proposed by Wenger (1998) for the purpose of understanding the learning process in CoPs, the theory has four premises: (a) humans are social beings; (b) "knowledge is a matter of competence with respect to valued enterprises" (p. 4); (c) "knowing is a matter of participating in the pursuit of such enterprises, that is, of active engagement in the world" (p. 4); and (d) "meaning - our ability to experience the

world and our engagement with it as meaningful - is ultimately what learning is to produce” (p. 4).

Learning in this model involves social participation (Wenger, 1998), which is the integral and inseparable aspect of social practice (Lave & Wenger, 1991). Participation is a process of being an active participant in social communications as well as constructing an identity in relation to these communities (Wenger, 1998). Lave and Wenger (1991) proposed the concept of *legitimate peripheral participation* (LPP) in a community of practice to explain the learning process. It addresses how an individual gradually moves from new-comer to old-timer in the community. LPP evolves from situated learning and apprenticeship, and, as a result, it has incorporated the characteristics of these two important learning theories. LPP addresses the relation between newcomers and old-timers and the way individual learners gain access to sources for understanding through growing involvement (Lave & Wenger, 1991).

According to Wenger (1998), social theory of learning integrates four components to characterize social participation as a process of learning and knowing, including identity, meaning, practice, and community. *Identity* refers to the changes to who we are through the engagement in a community. This element addresses the social formation of a person. In the current study, individuals’ levels of expertise were measured to understand how people categorized who they are in the profession and what their own skill levels are. *Meaning* is constructed through the negotiation required when individuals experience the world. Through the process of constructing meaning, individuals form their views of knowledge and knowing. The meaning may be inherent in conversation, decision-making processes, problem-solving processes, past experiences with similar claims, formal and informal training, books, meeting notes, historical documents, images, or rules. There are several ways and perspectives with which to

empirically investigate the meaning of an individual's work and practice. For instance, researchers can conduct discourse analysis to understand what and how meaning is formed. Social network analysis can reveal how meaning is conveyed and created. Content analysis of the written documents, e.g. meeting notes or email messages, can also explain how meaning is constructed. The current study explored whether domain-focused epistemic beliefs could be used to comprehend individual members' understanding of the field. *Practice* happens when individuals are engaged in actions, negotiating meaning with each other, and developing a shared repertoire of resources, such as experiences and stories to solve common problems. Practice in this study was represented through participation in a firm-hosted online community whose members were all engaged in the field of design practice. *Community* denotes that members develop a sense of belonging to a group where individuals are engaged in discussion and knowledge-sharing. This component gives primacy to norms and rules and is concerned with how people share and contribute their knowledge.

Statement of Problem

There are still several issues regarding communities of practice that have not yet been studied in the literature. These issues fall into three main areas: challenges of knowledge contribution, help-seeking processes, and a lack of research investigating the relationship between epistemic beliefs and knowledge contributions in online CoPs.

Challenges of knowledge contribution.

One of the key characteristics of CoPs is engagement. The extent of members' active participation in the community is one important criterion of a successful community. People who only observe the community are called "lurkers," and it is common for over ninety percent of

online communities' members to be lurkers (Nielsen, 2006; Preece, Nonnecke, & Andrews, 2004). The underlying challenges that prevent people from contributing their knowledge to online communities have been discussed in several studies. One of the barriers is that community members tend to shy away from contributing knowledge because they are afraid that their posts may not be important or completely accurate (Ardichvili, 2008; Ardichvili, Page, & Wentling, 2003). People are also concerned that information may be interpreted or used out of context by those who do not fully understand its implications (Damodaran & Olphert, 2000). Because lurkers think that they do not have control over the knowledge they could potentially share if they weren't afraid and that they may not have other chances to explain the information they offer, they may hesitate to share what they know. The fear of criticism and of misleading others holds them back from sharing their knowledge.

In the current research, it was hypothesized that these obstacles to active participation might arise from individuals' epistemic beliefs. Though the fear of sharing inaccurate knowledge and concerns about misinterpretation of knowledge are both related to an individual's belief about the nature of knowledge, they suggest two conflicting ideas. The fear of not sharing accurate knowledge implies that these individuals believe that knowledge is simple and certain, i.e., that there are right and wrong answers. However, concerns about misinterpretation of knowledge may indicate that these individuals believe that knowledge is contextual, and not absolute. While previous research about barriers to knowledge contribution has demonstrated a relationship between epistemic beliefs and knowledge contributions, those findings did not identify how the belief in either certain knowledge or contextual knowledge might impact someone's willingness to contribute their knowledge.

Nevertheless, Constant, Kiesler, and Sproull (1994) have found that attitudes about knowledge-sharing depend on the form of knowledge. People are more likely to think that tacit/know-how knowledge (e.g., fixing a software bug) belongs more to its knowledge holders than does explicit knowledge (e.g. a computer program that the knowledge holder developed), and this perception influences their inclination to share knowledge. In addition, different types of knowledge require different ways of learning (Nonaka & Takeuchi, 1995). For example, for design professionals, a better way of learning how to provide a more suitable solution to a client may be through discussing the case with other experienced designers, as opposed to reading a book about strategies and principles of how to negotiate with a client. Since ways of learning knowledge, a main component of epistemic beliefs, are connected to different forms of knowledge and different forms of knowledge are related to an individual's perception about sharing knowledge, there might be a relationship between ways of learning knowledge and perception about sharing knowledge, which can affect knowledge contributions. However, there is a lack of empirical findings to support the link.

Help-seeking process and contributing knowledge.

Second, the importance of the current research problem was based on the previous research about the help-seeking process. Interaction within a community can be understood by examining two different types of behaviors: help-seeking and help-providing. One main purpose of online CoPs hosted by firms is to help current customers find information that they need. Hence, in these communities, a help-seeking process usually occurs before other types of behaviors. Nelson-Le Gall (1981) proposed that the help-seeking process includes five steps: becoming aware of a need for help, deciding to seek help, identifying potential helpers, using strategies to elicit help, and evaluating help-seeking episodes. Based on this model, Mercier

further developed a cognitive model of help seeking which incorporates a problem-solving process and integrates user's background knowledge (Mercier & Frederiksen, 2008). Mercier elaborated the first two steps in Nelson-Le Gall's model, calling it the setting of a help goal. Setting a help goal includes recognizing an impasse, diagnosing the impasse, and establishing a specific need for help. After setting a help goal, the individual would find appropriate help, comprehend the help, and evaluate the help. Help evaluation then becomes the feedback for setting another help goal, finding appropriate help, and comprehending that help.

In fact, these two process models can also serve as decision models for contributing knowledge to online communities. Deciding whether or not to share knowledge and what content to share depends on the results of evaluating help. For example, during the evaluation, if individuals learn that the help they find does not work, they may decide to keep looking for help. In this case, one of the next steps that they may take is to post a question and share their failure experience of why the help did not work. In the same vein, during the evaluation process, they may find consistency between their experience and the help they find, or they may find some other useful information that has not yet been shared in the communities. In these situations, they may decide to share the knowledge and experience that they gained during the process. Whether they decide to make a knowledge contribution or not, this additional episode can become a source of feedback in the evaluation episode, as well as the episode of setting up a help goal, finding appropriate help, and comprehending help.

Several studies on the help-seeking process have discovered an impact of epistemic beliefs on online searching modes and decision-making patterns (Hofer, 2004; Mason & Boldrin, 2008; Whitmire, 2003). Aleven, Stahl, Schworm, Fischer, and Wallace (2003) also suggested using individual epistemic beliefs to understand how a person utilizes an interactive help system.

Depending on the individual's epistemic beliefs, different types of help may be appropriate. Since knowledge contribution may be highly connected to help-seeking behaviors, and epistemic beliefs can help understanding knowledge contribution, relationships among epistemic beliefs and knowledge contribution are expected. However, there is a lack of empirical research investigating these connections.

Lack of research on knowledge contribution in online communities of practice.

There is a lack of research on contributing knowledge to online CoPs. Existing research has explored some individual factors that influence community members' contributions. For instance, work experience contributes to positive attitudes about sharing expertise (Constant et al., 1994). Peddibhotla and Subramani (2007) found that people shared their knowledge in online communities usually due to two types of motivation: self-oriented motives (e.g., enhancing one's own understanding of topic) and other-oriented motives (e.g., reciprocity). Self-oriented motives relate to better quality and lower quantity of contribution, while other-oriented motives drive higher quantity and lower quality of contribution. Wiertz and Ruyter (2007) indicated that members' perception of the quality of content in communities had a direct effect on quantity of knowledge contribution.

While several studies have indicated the influence of individual characteristics on contributing knowledge, there is a scarcity of research on the impact of epistemic beliefs. Only two related studies by Bråten and his colleagues were found (Bråten & Strømsø, 2006; Bråten, Strømsø, & Samuelstuen, 2005); however, their participants were undergraduate students, who are the typical subjects of research in the field of epistemic beliefs. More in-depth reviews are presented in Chapter 2. The dependent variables that they used to measure Internet communication were self-reported questions that asked students to answer their usage preference

for discussion through the Internet. These questions are still distinct from knowledge-sharing and contributions to online CoPs. Also, there might be a difference between self-reported questions and actual behaviors.

Interaction between expertise and epistemic beliefs in knowledge contribution.

The discussion above indicates that there is a connection between epistemic beliefs and contributions to online CoPs, yet there is a lack of research that investigates how that relationship may be influenced by an individual's level of expertise. Given that experts/authorities are one source of knowledge, several theories of epistemic beliefs have included beliefs about expertise. A study conducted by Kuhn (1991) included the interview question, "Do experts know for sure what causes event A?" to investigate this type of belief. Her findings indicate that an individual with a less sophisticated belief regards expertise as the basis for knowing. In contrast, an individual with a sophisticated belief would be skeptical about expertise. Additionally, in Hofer and Pintrich's model (1997), the belief about expertise is incorporated into an individual's justification for knowing, which explores how the person evaluates expertise. Therefore, belief about expertise is considered a part of epistemic beliefs. Although individuals' self-reported expertise and epistemic beliefs might be related, these two factors have not been empirically investigated. While several studies have pointed out that epistemic beliefs would be different for individuals in different grade levels¹ (e.g., college students versus graduate students) (Jehng, Johnson, & Anderson, 1993), existing research has not studied that relationship in the context of community of practice.

¹ Though the grade levels are not equivalent to expertise, they are highly related.

Although a relationship between epistemic beliefs and expertise might exist, how the interaction affects knowledge contributions in an online CoP hosted by a firm is thus far unknown. For instance, experts might act differently in the community based on the strength of their belief in authority. According to the logic of the barriers to knowledge contribution reported by Ardichvili, Page, and Wentling (2003), if an individual with a strong belief in authority and expertise thinks that he is an expert in the field, he might be more likely to contribute his knowledge, since he has a stronger belief in himself. However, a novice with a strong belief in expertise might hesitate to contribute his knowledge because he thinks only experts should contribute their knowledge. Furthermore, an expert with a weak belief in expertise might hesitate to contribute because he believes knowledge can be accessed without experts or that experts are sometimes wrong. In summary, not only the components of expertise and epistemic beliefs, but also the interaction between them, are related to knowledge contributions. However, there is a lack of empirical research investigating these connections among epistemic beliefs, levels of expertise, and decisions to contribute to a community.

Purpose of the Study

As a response to the problems discussed in the previous section and the current lack of empirical research about them, the focus of this study was the exploration of the relationships among epistemic beliefs, level of expertise, and members' contributions to an online CoP hosted by a firm. The analysis was focused on individuals in the community. Since this study adopted an instrument of epistemic beliefs developed by Hofer (2000) that was most often used in the context of higher education, the dimensions and structure of epistemic beliefs were re-examined.

Level of expertise was used because it has been indicated to be a more effective explanatory variable than age and education regarding information-seeking (Aleven, Stahl, Schworm, Fischer, & Wallace, 2003). Several scholars in the field of epistemic beliefs have also stated that age, gender, and grade levels might not be sufficient to explain differences in epistemic beliefs (Baxter Magolda, 2002; Hofer, 2004; Kuhn, 2000; Wood & Kardash, 2002). Therefore, the effects of age, gender, and levels of expertise on knowledge contributions were compared in this study, in order to better understand the relationship between epistemic beliefs and knowledge contributions.

For the purpose of capturing community members' contributions more comprehensively, both self-reported contributions and actual contributions to the online communities were observed. As suggested by Peddibhotla and Subramani (2007), the actual behaviors reflected both the quantity and quality of contributions.

This study explores the following questions:

1. What is the structure of domain-focused epistemic beliefs relative to the structure, stability, source, and justification of knowledge in the field of design?
2. How do demographic characteristics – age, gender, expertise – relate to individual levels of contribution to an online community of practice hosted by a firm?
3. How do individuals' design-focused epistemic beliefs relate to their levels of contribution to an online community of practice hosted by a firm?
4. How does the interaction between expertise and design-focused epistemic beliefs relate to individual levels of contribution to an online community of practice hosted by a firm?

Based on the social theory of learning and the statement of problem, a working model of the potential relations between individuals' age, gender, level of expertise, epistemic beliefs, and

contributions to an online community of practice hosted by a firm is proposed (see Figure 1). The hypotheses of the relations are presented below. First, age, gender, and level of expertise significantly relate to individuals' levels of contribution to a community. Specifically, individuals' levels of expertise are positively associated with contributions. The more expertise that individuals have, the more likely they are to contribute and to have higher quality contributions. Second, individuals' design-focused epistemic beliefs relate to their level of contribution. Those with less belief in simple and certain knowledge, less belief about authority, and more belief in personally evaluating knowledge claims may have more contributions and higher quality contributions. In addition, there is an interaction between expertise and design-focused epistemic beliefs in contributing to individual level of contribution.

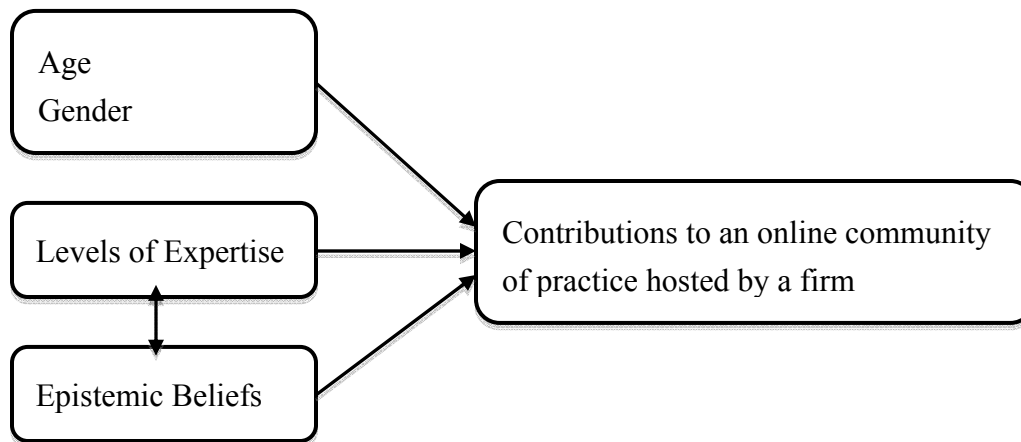


Figure 1. Model of the proposed relations between age, gender, levels of expertise, epistemic beliefs, and contributions to a community

Significance of the Study

A critical question that has been asked frequently by scholars in studies on communities of practice is how to encourage people to actively participate in a community and contribute their knowledge. Individual epistemic beliefs might provide a better explanation of contribution behavior and a new perspective for the theory of CoPs. Existing discussions on epistemic beliefs

in formal education settings could conceivably bring a fresh perspective to online CoPs. This study provided empirical findings related to the relationship between epistemic beliefs and formed a basis for future research.

This study also provided empirical findings to extend the theories of epistemic beliefs to adult learners in a previously unexplored learning context. The traditional view has focused more on school-type tasks than on job or everyday tasks (Buehl, 2008). Based on her previous studies, Schommer (1998) posited that epistemic beliefs have a multitude of implications in on-the-job training. There is a lack of studies on adults within this kind of online learning and professional development environment. Moreover, most traditional research has studied the impact of age, grade level, and knowledge domain on epistemic beliefs. This research took levels of expertise into consideration, which might offer a more comprehensive/accurate explanation of epistemic beliefs.

This study may also add new perspectives to the practice of CoPs, by identifying characteristics of key contributors. According to Schommer (1998), “Epistemological beliefs may be the critical factors that distinguish between individuals that we would want to be on our workforce and those that we don’t want” (p. 134). CoPs could be more active and vibrant by setting community policies which facilitate and encourage participation for these key contributors.

Finally, this research could enhance the understanding of characteristics of online CoPs. Existing research has suggested that the design of online learning environments should correspond with individuals’ epistemic beliefs, so that individuals can gain more, learn better (Aleven et al., 2003; Demetriadis, Papadopoulos, Stamelos, & Fish, 2008; Windschitl & Andre, 1998), and encounter fewer challenges while interacting with their environments (Jacobson &

Sprio, 1995). In other words, the various design elements of online CoPs, such as software environment employed (e.g., instant messenger or bulletin board) and governance structure chosen (e.g., norms to present people's identity), might need to correspond to community members' epistemic beliefs as well. This research provided a foundation for transferring the theories of epistemic beliefs to the context of online CoPs. Epistemic beliefs could be one of the key characteristics of online communities of practice, and this should remain in the awareness of these communities' administrators.

Limitations

Although this study raised a critical issue in the area of epistemic beliefs and online CoPs, there were some limitations. First, web-based surveys have been adapted for use in the study, instead of computer-based or paper-based surveys. This method was deemed as a more appropriate way to collect data in this context, since participants were from all over the world, a typical characteristic of learners within online learning environments. This methodology might have led to decreased reliability and/or validity. However, Hardré, Crowson, Xie, and Ly (2007) tested various questionnaires on beliefs, values, perceptions and motivation with computer-based, web-based, and paper-based administration, and found the reliabilities across administration conditions did not change substantially. Therefore, while it was helpful to keep this potential problem in mind when generating implications, it was not a serious concern in this study.

Another possible limitation was the instrument used for measuring epistemic beliefs. This research adopted Hofer's (2000) questionnaire; however, her questionnaire probably does not represent all dimensions of epistemic beliefs. As Hofer contended, the instrument could be

improved by adding items that allow for different ways of justification (e.g., assessment of expert opinion) and other sources of knowledge (e.g., individual construction of meaning). The focus of this current research was to provide a basis for transferring epistemic beliefs to adult learners in the context of online CoPs. Future research may focus on the improvement of the instrument for adult learners in online learning environments.

Possible inconsistency of measurement of the quality of comments across moderators may pose another limitation. Measurement of the quality of comments was based on moderators' judgments of their value. Although moderators took part in a two-hour training, case discussions with other moderators and an overview of moderator guidelines, judgments are subjective and might still not be reliable across moderators. The decision to adopt this measure to understand the quality of contributions has been made due to a consideration of efficiency. In order to overcome the measurement limitation, this research included other measures of contributions (i.e., quantity of contributions and self-reported contributions). Finally, due to self-reporting, the level of expertise might not be able to accurately reflect research participants' expertise. In order to overcome this limitation, this research included three questions to evaluate levels of expertise. Through the diverse measurements of contributions and expertise, these two variables were expected to be represented more precisely.

Definition of Terms

An online community of practice hosted by a firm indicates an activity system which includes groups of people with a common interest, belief, activity, or goal who interact in a virtual environment across time, geographical, and organizational boundaries. This type of

community is hosted by firms for the purpose of helping their current customers to better use the firms' services or products.

Epistemic beliefs are defined as individual beliefs about the nature of knowledge and knowing (Hofer & Pintrich, 1997). Another similar term that has been widely used in the field is *epistemological beliefs*. According to Kitchener (2002), epistemological beliefs are beliefs about the field of epistemology and the study of knowledge. Since this is not the focus of the study, the term *epistemic beliefs* is adopted.

Knowledge contribution is value-added content based on a community member's knowledge (i.e. information, skills, or expertise) which is shared with the community.

Levels of expertise are measures based on levels of experience with the software, frequency of software use, and years of experience in the design profession.

Chapter 2

Literature Review

In this chapter, past research on levels of expertise in the field of design and the relationships between levels of expertise and contributions to communities of practice is examined followed by recent studies on personal epistemology. Existing models of personal epistemology are reviewed in order to introduce the field, including unidimensional models and multidimensional models. In light of these multidimensional models, different instruments, their studied context, reliability, and validity, are discussed. These reviews then lead to the theoretical debate of whether the construct should be understood through domain-general, domain-focused, or domain-specific models. Finally, research on the influence of belief on participation in online activities is reviewed.

Expertise and Communities of Practice

The nature of expertise has been extensively discussed in previous studies, especially in the domains of chess, physics, medicine, and sports. In the following section, the nature of expertise, specifically in the field of design, and previous empirical findings on the relationship between expertise and contributions to online communities of practice are reviewed.

Nature of expertise.

In general, expertise develops over time as a person engages in the domain longer (Ericsson & Charness, 1994); the development reaches a peak then starts declining (Cross, 2004). The peak is reached at different ages for different fields. However, not everybody can reach the peak (Dreyfus & Dreyfus, 1986). Previous studies have discussed what experts know that novices do not. These include not only quantitative but also qualitative differences.

Mayer (2003) summarized four qualitative differences between experts and novices in physics. First, experts store domain knowledge in larger and interrelated cognitive chunks, so that the knowledge can be accessed more quickly and efficiently. Second, experts build more sophisticated representations of the problem and connect the representations to the domain knowledge. Third, experts sort problems based on structural similarities and principles required to solve them. Last but not least, experts and novices apply different strategies to solve problems. Experts tend to work forward from the given to the unknown conditions. In contrast, novices instead tend to work backward from the goal to the given. Their cognitive processes are also different. Experts tend to collect a larger number of examples of problems and solutions, to conceptualize the experience, and to store them into an abstract form.

Based on the above differences, there are five stages of qualitative development from novices to experts (Dreyfus & Dreyfus, 1986): novice, advanced beginner, competent, proficient, and expert. *Novice* starts with recognizing various context-free objective facts and features. These facts and rules are learned without considering context, which may cause transfer problems. After a *novice* collects considerable experience, a *novice* becomes an *advanced beginner*. Through practical experience, an *advanced beginner* can identify situational elements from the environment and form situational rules. He refers to both situational rules and context-free rules to solve problems. As an *advanced beginner* learns more, he becomes confused about what is important. As a result, a *competent* performer develops a hierarchical process in order to make decisions more effectively and efficiently. By examining a situation as a set of facts, he can focus on specific key factors, compare plans, and determine a better plan to improve his performance. A *proficient* performer develops intuitive ability to organize tasks and to apply patterns in solving problems. The intuition allows the proficient performer to effortlessly connect

previous experiences and the new context. However, the *proficient* performer sometimes still consciously analyzes how best to do it. Unlike the *proficient* performer, when things develop normally, the *expert* in the last stage doesn't make deliberative decisions. They intuitively know their abilities and boundaries. When time permits and outcomes are important, the *expert* may still consciously make decisions, but the process is different from that of the less experienced individual. The expert would critically evaluate his intuitive problem-solving process. Depending on their different levels of expertise, individuals require different types of learning materials (Kalyuga, 1998).

Expertise in design.

Design is a domain that concerns the complexity associated with ill-defined problems, requiring a continuous dialog between client and designer. However, the differences between experts and novices in design are similar to the differences in other fields (Purcell & Gero, 1998). Expert designers possess more knowledge and different types of knowledge than novices. Qualitatively, experts store information in larger chunks which allow them to have more efficient and more organized cognitive processes than novices. Experts consider perceptual and functional features and relations between the two at the same time. In the early part of the problem-solving process, experts spend more time to recognize key constraints and identify issues in a particular design situation (Ho, 2001). Later in the problem-solving process, they focus more on solutions than on the problems (Atman, Chimka, Bursic, & Nachtmann, 1999). Experts are more likely to consider alternative solutions and use these solutions as a way of evaluating problems and solutions. Novices instead focus more on the specific technical features (such as design elements and constraints) related to an object (Calabrese & Marucci, 2006). When novices fail to handle a problem, they tend to redefine the problem and approach the goal

of this new problem (Ho, 2001). In terms of their relationship with clients, experts can more precisely understand constraints and are more able to take into account other stakeholders' viewpoints (Bonnardel, 2000).

Expertise and contributions in CoPs.

Little attention has focused on how expertise is related to individuals' contributions to online communities of practice. There are only two related articles that have researched knowledge contribution within a company and its relationship with expertise. First, Constant, Kiesler, and Sproull (1994) explored how different kinds of knowledge, tacit and explicit knowledge, influence one's attitude of knowledge ownership and how this attitude drives sharing behavior. They found that work experience (years of working full time) was positively correlated with attitudes favoring sharing and directly predicted sharing behavior. A sample question on information sharing is "what is the likelihood you would share" (p. 408). The questions were rated on 7-point Likert scales.

Constant, Sproull, and Kiesler (1996) further studied whether experience and expertise could predict the usefulness of advice. Experience included years of firm experience and years of experience in the computer industry. The question of expertise was "How informed are you on the subject matter of this question" (p. 123), and it was rated on a 10-point Likert scale (1=novice and 10=expert). To measure usefulness of advice, participants awarded each reply from \$0 to \$25, and they also rated whether the problem was solved. The findings indicated that individuals' expertise and experience working in a firm were positively related to the usefulness of their reply. Both studies concluded that there was a positive relationship between expertise and knowledge contributions.

Unidimensional Models of Personal Epistemology

From a historical perspective, unidimensional models were developed first. The first model was proposed by Perry (1970). Following Perry, many researchers contributed to this area, including *Women's Ways of Knowing* by Belenky and her colleagues, Baxter Magolda's *Epistemological reflection Model*, King and Kitchener's *Reflective Judgment Model*, and Kuhn's *Argumentative Reasoning* (Hofer & Pintrich, 1997). Individual beliefs in these types of models were characterized by a single perspective on a developmental timeline (Buehl, 2008).

Perry scheme.

In the early 1950s, William Perry (1970) began two longitudinal interview studies that explored how students made meaning of their educational experiences. In the first study, thirty-one freshmen were interviewed. They were asked the following two questions: (1) "Would you like to say what has stood out for you during the year?" (2) "As you speak of that, do any particular instances come to mind?" In the second study, Perry and his colleagues extended and spelled out the sequence that they had detected in the first study, created an articulated developmental scheme, and tested the validity of this scheme. Based on the heuristic studies, they outlined this first model, addressing intellectual and ethical development.

In Perry's two studies, a *Checklist of Educational Views* (CLEV) was used in order to get a profile of students' development of epistemological positions and to initiate an interview. The CLEV, containing 46 statements, was originally developed by Perry in 1968. Its initial purpose was to allow students to report their own thinking and value systems; these would then be compared to the development of Perry's scheme. Students would rate to what extent they agreed with a statement and how difficult it was to decide their level of agreement. Shommer's *Epistemological Belief Questionnaire* (1990) and Wood and Kardash's *Epistemological Beliefs*

Survey (2002) have included several questions from the CLEV, such as “If professors would stick more to the facts and do less theorizing, one could get more out of college.”

Perry’s model includes nine positions/stages of cognitive and affective development that are typically clustered into four sequential categories: dualism, multiplicity, relativism, and commitment within relativism. *Dualism* encompasses positions one and two, in which authorities are expected to know the truth and to convey their knowledge to the learner. In position one, an unquestioned view of truth exists. In position two, different perspectives are acknowledged, but individuals believe that knowledge is either right or wrong. *Multiplicity* encompasses positions three and four, in which students acknowledge diversity of knowledge. In position three, an authority remains the source of answers or the source of a method to find the answers, but in position four, an authority is the source of ways to think. In this position, students accept that most knowledge is not yet known, and that people may hold their own opinions. *Relativism* encompasses positions five and six. Individuals in this category perceive knowledge as relative, contingent, and contextual. In position five, students only recognize that knowledge can be evaluated; in position six, they further understand that they have a responsibility to make their own judgment. In the final category, positions seven through nine, *commitments within relativism* act as affirmations of one’s own identity (Perry, 1970). However, positions in this category were not clearly specified in Perry’s work (Hofer & Pintrich, 1997).

Perry (1970) indicated that the process of growth can also be reversed. Three reverse conditions may happen: temporizing, retreat, and escape. *Temporizing* means a pause in growth for a year or more with hesitation to take the next step. This reversed condition may happen at any position. *Retreat* indicates that students become entrenched in dualism, positions 2 or 3, because they highly depend on authority. *Escape* means that students hold passive attitudes or

opportunistic alienation, when they engage in positions 4 and 5, in order to deny responsibility of making commitments in a relative world. In other words, Perry's scheme is a dynamic model which posits change over time and movement in different directions.

Hofer and Pintrich (1997) noted several limitations to Perry's original study. First, the sample in Perry's study was elite college students who were white males studying at Harvard University during the 1950s. Second, although there were three positions in commitment within relativism, these positions were not as clear and specified as the lower positions. Associated with this last point, the third limitation is a difficulty in operationalizing the scheme and evaluating the change of the process. This barrier is due to not only the theory's lack of specificity, but also the measuring tool's lack of efficiency.

Belenky et al.'s women's ways of knowing.

In response to the major limitation of the *Perry Scheme*, Belenky, Clinchy, Goldberger, and Tarule (1986) focused on the issue of women as knowers and learners. Their preliminary goal was to classify data on the basis of the Perry scheme; however, the lack of fit led them to develop a new scheme of five epistemic perspectives. Their samples were selected from two different populations: Ninety women were students from one of six diverse academic institutions, and forty-five women were participants in family agencies where they were seeking information about parenting. Their interview protocols were composed of sections on gender roles, relationships, education, real-life moral dilemmas, and ways of knowing based on the frameworks of Perry, Gilligan, and Kohlberg (Belenky et al., 1986).

There are five perspectives on women's ways of knowing. *Silence*, the first perspective, refers to a voiceless and passive existence. External authority represents the absolute truth. In the next perspective, *received knowledge*, women believe that they are capable of receiving and

reproducing knowledge. The source of this knowledge is derived from authority, and there is only one right answer. This perspective is parallel to dualism in the Perry scheme (Hofer & Pintrich, 1997). Women in *subjective knowledge*, the third perspective, believe themselves to be the sources of truth; truth and knowledge are perceived subjectively. This position is similar to Perry's multiplicity. In the next position, *procedural knowledge*, women adopt objective and systematic perspectives. This position includes separate knowing and connected knowing, which denotes the relationships between knowers and the objects/subjects of knowing. *Separate knowers* assume everyone may be wrong, and that they themselves have the obligation to examine ideas critically. *Connected knowers* believe that the most trustworthy knowledge comes from personal experience, so they develop procedures for gaining access to other people's knowledge. This position is similar to relativism within the Perry scheme. *Constructed knowledge*, the fifth position, refers to an integration of subjective and objective ways of knowing. Knowers are actively involved in the process of knowledge construction; as a result, knowledge and truth are contextual. This is aligned with the last position in the Perry scheme, commitment within relativism.

Compared with Perry's study, Belenky et al. (1986) expanded the understanding of epistemic beliefs by emphasizing the source of knowledge and truth. One of the criticisms of Belenky et al. (1986) is that the exclusively female samples did not provide a valid method to evaluate the gender-related nature of the findings. Additionally, the inclusion of women who were not in school makes it difficult to draw meaningful conclusions about the differences in ways of knowing between genders (Hofer & Pintrich, 1997).

Baxter Magolda's epistemological reflection model.

Unlike the studies done by Perry (1970) and Belenky et al. (1986), Baxter Magolda (1992) conducted a longitudinal interview study with both male and female college students, so that gender-related patterns were observed in her model. She began with 101 students from Miami University in Ohio, including 51 females and 50 males. Eighty students participated through their four years of college, seventy of them kept participating after graduating from college, and 39 remained through year 12. During the college interview, the study addressed six areas: the individual's role as a learner, the role of instructors and peers in learning, the individual's perception of evaluation of his or her work, the nature of knowledge, and educational decision-making. In the post-college phase, the interview continued to explore how participants learn and come to learn. The participants were asked to think about important learning experiences that had taken place since the previous interview and to reflect on these experiences.

The structure of the epistemological reflection model also coincides with Perry's and Belenky et al.'s perspectives. Compared with Belenky et al., Baxter Magolda (1992) also found a similar structure of personal epistemology between men and women. However, she did indicate gender-related patterns within each position. *Absolute knowers* believe that those in authority have all the answers. Peers can only share and explain materials to each other. There are two patterns in the position of absolute knowers, a receiving pattern and a mastery pattern. *Receiving pattern knowers*, who are primarily women, acquire knowledge through listening and recording information. On the contrary, *mastery pattern knowers*, primarily men, acquire knowledge through active involvement to remember the material. *Transitional knowers*, the second position, accept the uncertainty characteristics of knowledge. For example, transitional knowers believe

that math and science are certain and the humanities and the social sciences are uncertain. These knowers believe that teachers and evaluations in the uncertain area should focus on understanding the knowledge rather than memorizing it. There are also two patterns in this position, an interpersonal pattern and an impersonal pattern. *Interpersonal pattern knowers*, primarily women, prefer to learn in the uncertain areas and focus on sharing views. *Impersonal pattern knowers*, primarily men, focus on defending their views and being challenged to think. *Independent knowers* believe each individual has his or her own truth. This third position includes an *interindividual pattern* for the majority of women and an *individual pattern* for the majority of men. Interindividual pattern knowers value others' views and may change their views accordingly; individual pattern knowers struggle to hear others' views. *Contextual knowers*, similar to the last position in the Perry scheme, are capable of applying knowledge in particular contexts and making judgments based on evidence. This position often appears after graduating from college; at this point, gender-related differences also decrease.

Baxter Magolda (1992) also indicated three distinct phases within contextual knowing that emerged in the post-college interviews. First, individuals use *external formulas*, e.g., others' perceptions, to decide what to believe. Second, in *search of internal authority*, individuals reach a point of developing their internal authority and a sense of self that could be influenced but not overwhelmed by others' perceptions and approval. One participant in this study took three years after college to come to this phase. In the third phase, individuals focus on *establishing an internal foundation of belief* for self-authorship during their late twenties and early thirties. Those in this phase acquire some principles by interacting with others. These principles serve as the core from which his or her life and decisions operate (Baxter Magolda, 2002).

The epistemological reflection model is focused more on the nature of learning in the development of adulthood from ages 18 to 30. Baxter Magolda provided solid descriptions of learning in the post-college years, including learning in the workplace and learning from interactions with family members. She suggested that this study had not yet been completed. Future research is needed to continue tracing development into adulthood (Baxter Magolda, 2002). Additionally, similar to a limitation in Perry's study, the sample in Baxter Magolda's study was also composed of a mostly white and middle-class sample. The extent to which this epistemic development transfers to other populations requires further examination.

King and Kitchener's reflective judgment model.

King and Kitchener created the *Reflective Judgment Model* based on the work of Perry and John Dewey (King & Kitchener, 1994). The model is defined as "the development of complex reasoning in late adolescents and adults, and how the epistemic assumptions people hold are related to the way they make judgments about ill-structured issues" (King & Kitchener, 2004, p. 5). They conducted a ten-year longitudinal and cross-sectional interview study with individuals ranging from high school students to middle-aged adults (King & Kitchener, 1994). A wide-variety of students and nonstudent subgroups were studied. They developed an extensive interview protocol, the *Reflective Judgment Interview* (RJI), to explore individuals' foundational assumptions concerning knowledge and how it is gained. In the protocol, five standard issues were included, including how human beings were created, how the pyramids were built, etc. These issues guided conversations about the probe questions, which were focused on how a respondent arrived at a point of view, how certain he or she was about this perspective, how he or she assessed alternative interpretations, and how he or she made sense of an authority's perspective.

The reflective judgment model is a developmental stage model (King & Kitchener, 2002) with seven qualitatively different stages. Both the view of knowledge and the concept of justification are explained in each stage. The seven stages can be further categorized into three periods: *prereflective* (Stages 1 to 3), *quasi-reflective* (Stages 4 to 5), and *reflective* (Stages 6 to 7). As mentioned in the review by Hofer and Pintrich (1997), the prereflective period is similar to the initial positions in previously mentioned models; the quasi-reflective period is similar to Perry's multiplicity and relativism; and the final period is close to commitment within relativism.

In the first stage, knowledge is absolute, not understood as an abstraction, and can be acquired by direct observation. Beliefs need no justification; alternate beliefs are not perceived. King and Kitchener (2002) concluded that this stage is rare and only happens in the youngest high school samples. The second stage, similar to Perry's dualism, hypothesizes that knowledge is obtained through authorities. Stage three accepts that knowledge can be temporarily uncertain; in this area, beliefs are defended as personal opinion. Stage four, similar to multiplicity, states that knowing always involves an element of ambiguity, and justification is achieved by means of giving reasons and using evidence. In stage five, which is similar to relativism, knowledge is contextual and subjective, and beliefs are justified through the rules of inquiry within a particular context. In stage six, knowledge is constructed into individual conclusions, and justification is reached by comparing evidence and opinions from different perspectives. The last stage is characterized by the use of critical inquiry and probabilistic justification to guide knowledge construction.

The reflective judgment model is particularly noteworthy for its in-depth research on views of knowledge and justification for ill-structured problems. It also makes unique contributions in its elaboration of the upper levels of Perry's scheme. However, the interview

protocol did not provide a good way to explain development in the post-college period. As a result, the researchers were not able to specify how the development stages are related to real-world job and family problems, even though they interviewed participants in their post-college periods. Another limitation is that only trained raters are permitted to utilize the reflective judgment interview, which is too time- and money-consuming (King & Kitchener, 2004; Hofer & Pintrich, 1997). This becomes a barrier to wider use; therefore, scholars in this area have started to focus on developing other assessment instruments, such as the Reasoning about Current Issues test (RCI) (King & Kitchener, 2004, Wood, Kitchener, & Jensen, 2002).

Kuhn's epistemological reasoning in everyday life.

Similarly to King and Kitchener, Kuhn (1991) also questioned how individuals respond to ill-structured problems, but she focused on argumentative reasoning for everyday, real-life problems. Subjects were asked to generate causal explanations for the following social problems: (a) What causes prisoners to return to crime after they're released?; (b) what causes children to fail in school?; and (c) what causes unemployment? She interviewed individuals from four age groups: teens, 20s, 40s, and 60s. There were 40 participants in each age group, and gender and educational levels were equally distributed. There were two interview meetings for each subject, each of which took about 45 to 90 minutes. The interviews took place in the participants' homes or work environments. Similar to King and Kitchener's interview protocol, for each issue Kuhn included questions regarding proof (e.g., "Could someone prove that you were wrong?"), expertise (e.g., "Do experts know for sure what causes xxx?"), multiple viewpoints, origins of theories, and certainty of one's own perspective.

Kuhn's model included three categories of epistemic views: *absolutist* (similar to Perry's dualism), *multiplist* (similar to Perry's multiplicity), and *evaluative* (similar to Perry's relativism)

(Hofer & Pintrich, 1997). The *absolutist* believes that knowledge is objective and certain, and is derived from an external reality and authority. At the *multiplist* level, knowledge is comprised of opinions chosen by their holders and is not open to challenge. The *evaluativist* recognizes that opinions can be compared and evaluated through a framework of alternatives, evidence, and arguments in order to assess relative merits.

Another study performed by Kuhn and her colleagues in 2000, applied a quantitative method to evaluate an individual's level of epistemic understanding. They asked 2 questions for 15 items; each item contained a pair of contrasting statements from two individuals, Robin and Chris. The two questions were: (a) "Can only one of their views be right, or could both have some rightness?" and (b) If subjects selected "both could be right," they then asked "Could one view be better or more right than the other?" (Kuhn, Cheney, & Weinstock, 2000, p. 316). The 15 items consisted of three questions in each of the following domains: judgments of personal taste, aesthetics, value judgments, truth about the social world, and truth about the physical world. They found that the transition between the three categories of epistemic views may not happen simultaneously across different domains; personal taste and aesthetics usually come first, and truth judgments change last. This study concluded that domain matters in individuals' epistemic beliefs. They contended that merely considering age and education are not sufficient to explain the transition to an evaluativist level. Interestingly, most of the adults made the transition from an absolutism to a multiplist view, but less than half transformed from a multiplist to an evaluativist view.

Most previous studies and theories were discussions focused on college students, and there remained minimal understanding about how adults change their beliefs. If it is assumed that adults have already reached the highest levels development and their beliefs are stable, there is

no need to conduct further studies to understand adults' epistemic beliefs and how the beliefs correspond with behaviors. However, findings from Kuhn, Cheney, and Weinstock indicate that not all adults reach the highest level of epistemic beliefs, and their beliefs may not be the same across different domains. There is a need for further study of adults' beliefs on epistemology.

Kuhn's work is particularly noteworthy for its elaboration of the connection of epistemic theories to real-world reasoning and its explanation of the connection of epistemic beliefs to different domains. Hofer and Pintrich (1997) criticized discrepancies between Kuhn's interview protocol and the three levels in the epistemological reasoning model. The questions that Kuhn asked addressed proof, expertise, multiple viewpoints, origins of theories, and certainty; however, the assignment of responses and analyses were only based on expertise questions. Additionally, Hofer and Pintrich suggested that strength of argument, origins of theories, and attitudes toward the topic should be further explored.

Summary.

Table 2 provides a summary of unidimensional models of personal epistemology. There are similar developmental positions across these five models (Hofer & Pintrich, 1997). Perry's dualism is close to Belenky et al.'s silence, Baxter Magolda's absolute knowing, King and Kitchener's pre-reflective thinking, and Kuhn's absolutists. Similarly, Perry's multiplicity is close to Belenky et al.'s subjective knowledge, Baxter Magolda's transitional knowing, and Kuhn's multiplists. Relativism is parallel to Belenky et al.'s procedural knowledge, Baxter Magolda's independent knowing, and Kuhn's evaluatists. King and Kitchener's quasi-reflective thinking has characteristics from both multiplicity and relativism. Commitment within relativism, the highest category, is similar to Belenky et al.'s constructed knowledge, Baxter Magolda's contextual knowing, and King and Kitchener's reflective thinking.

Besides, different models still have various foci. Perry planted the seed of researching epistemic beliefs and initiated the developmental model. Since Perry's model had a limitation of excluding females, Belenky et al. and Baxter Magolda focused on women's ways of thinking and gender comparisons. Baxter Magolda compared both men and women's beliefs about knowledge and knowing and concluded that there is no difference between the developmental positions, but that women and men possess different patterns of knowing. King and Kitchener turned their focus toward reasoning and judgment processes about ill-structured issues and elaborated the upper levels of development of epistemic beliefs. Kuhn also examined reasoning processes about ill-structured problems, but focused on real-life problems which individuals might face in everyday life. Kuhn is also the first scholar who explored epistemic beliefs in a wide range of ages and found that age is not a sufficient explanatory variable regarding differences in epistemic beliefs. The findings from both Baxter Magolda and Kuhn suggest that future research is needed to continue tracing development into adulthood. Findings from King and Kitchener as well as Kuhn indicated that epistemic beliefs may be different within an individual across domains and topics.

Research methods used by these studies are mostly interviews and the analysis of journals (Bråten, 2008). These qualitative methods can capture rich details and elaborations of epistemic beliefs; however, the implications are limited due to the small sample size and are both labor and cost intensive (Wood & Kardash, 2002). Some instruments can only be conducted by trained raters, such as the reflective judgment interview from King and Kitchener. Although quantitative instruments have been developed in some unidimensional models, such as Perry's CLEV, King and Kitchener's RCI, and Kuhn's instrument, they are still not widely used.

Table 2

Summary of Unidimensional Models of Personal Epistemology

Author(s), Year	Subjects	Models	Relationships with other variables
Perry, 1970	I: 31 Ungrd II: 109 Ungrd were recruited in their first year. 67 completed four-year reports.	<u>Four categories</u> <ul style="list-style-type: none"> • Dualism • Multiplicity • Relativism • Commitment within relativism <u>Three reverse conditions</u> Temporizing, retreat, and escape	Not available: The majority was White, elite, and male college students.
Belenky, Clinchy, Goldberger, & Tarule, 1986	Two samples all female: 90 from academic institutions and 45 from those who participated in family agencies	<u>Women's Ways of Knowing</u> <ul style="list-style-type: none"> • Silence • Received knowledge • Subjective knowledge • Procedural knowledge: Separate knowing and connected knowing • Constructed knowledge 	The five perspectives are similar to Perry's male-focused model, but there is no sufficient evidence to support the similarity of development of personal epistemology between genders.
Baxter Magolda, 1992	101 Ungrd to postcollege, 12 years in total.	<u>Epistemological reflection Model</u> <ul style="list-style-type: none"> • Absolute knowing: Receiving or mastery pattern • Transitional knowing: Interpersonal or impersonal pattern • Independent knowing: Interindividual or individual pattern • Contextual knowing 	Ways of knowing were not different between genders, but gender-related patterns in knowing were found.
King and Kitchener, 1994	Secondary students, Ungrd, grad, and nonstudent adults	<u>Reflective Judgment Model</u> <ul style="list-style-type: none"> • Prereflective • Quasi-reflective • Reflective 	Students from social science programs scored higher than those in math programs.
Kuhn, 1991	Teens, 20s, 40s, and 60s	<u>Epistemological reasoning in everyday life</u> <ul style="list-style-type: none"> • Absolutists • Multiplists • Evaluatists 	Transition may not happen simultaneously across different domains. Considering only age and education did not explain the transition process well.

Multidimensional Models and Measurements of Personal Epistemology

The previously reviewed models are all unidimensional. Although different aspects had been addressed, e.g., the role of authority and the concept of justification, they were all treated as one single component to define positions on a developmental scale. Schommer (1990, 1992) pioneered the multidimensional conceptualization to examine how epistemic beliefs are related to academic cognitive and learning performance. The important breakthrough of Schommer's model is that five proposed distinct factors may or may not develop synchronously (Duell &

Schommer-Alkins, 2001). People may believe that knowledge is handed down by authority and be uncertain at the same time; these beliefs may be more or less independent. By conceptually transforming the model from unidimensional to multidimensional, she was able to develop a quantitative, multi-dimensional measurement of a person's epistemology, which brings an expedient alternative to interviews.

Schommer's multidimensional models.

In contrast to Perry's scheme, Schommer (1990) proposed that epistemic beliefs may be characterized as a set of independent beliefs. These beliefs are orthogonal and may present variations within individuals. These attributes function conjointly to shape epistemic beliefs. Students can be sophisticated in one belief and less sophisticated in another. This perspective is considerably different from Perry's category of epistemic beliefs, which contains progression levels and distinct borders between positions.

Schommer (1990) developed a self-report questionnaire with 63 items that measured epistemic beliefs along five dimensions. She initially hypothesized a five-factor model of epistemic beliefs: control of learning, speed of learning, structure of knowledge, stability of knowledge, and omniscient authority. There are two or more subsets of items within each dimension. *Control of learning* refers to the ability to learn as it is genetically determined rather than enhanced through education and experience; for instance, "An expert is someone who has a special gift in some area." *Speed of learning* is described as the belief that learning is quick or gradual; for example, "Successful students learn things quickly." *Structure of knowledge* characterizes the view that knowledge is organized as isolated facts rather than interrelated and integrated conceptions; for instance, "Most words have one clear meaning." *Simplicity of knowledge* characterizes the view that belief about knowledge is certain and absolute rather than

tentative and evolving; for example, “I don’t like the movies that don’t have an ending.”

Omniscient authority suggests that knowledge is handed down by authority rather than being derived from reason; for instance, “How much a person gets out of school depends on the quality of the teacher.” Factor analysis was conducted to determine which factors could represent the construct better. Schommer (1990) found that omniscient authority was the only one that did not form a factor.

After Schommer published her paper in 1990, many researchers followed her steps and modified the instrument or created new instruments based on her multidimensional model. Hofer and Pintrich (1997) found that two of the five factors, fixed ability and quick learning, appear to concern the nature of intelligence and beliefs about learning. These are not typical areas of epistemology. From a philosophical stance, epistemology is a study of the nature of knowledge and justification of beliefs (Derose, 2005; Steup, 2005). It addresses the following questions: “What are the necessary and sufficient conditions of knowledge? What are its sources? What is its structure?” (Steup, 2005, para. 1), and “What *makes* beliefs justified?” (Steup, 2005, para. 8). The unidimensional models introduced above only address the nature of knowledge and knowing. Hofer (2001) suggested that the construct of personal epistemology should only discuss beliefs about “the definition of knowledge, how knowledge is constructed, how knowledge is evaluated, where knowledge resides, and how knowledge occurs” (p. 355). According to the philosophical stance of epistemology and the construct in unidimensional models, the nature of intelligence and learning are not typically a part of the study of epistemology. Hofer and Pintrich (1997) proposed that beliefs about knowledge and knowing serve as a precursor that influences individuals’ beliefs about learning and the whole learning process.

Hofer and Pintrich (1997) indicated that the two factors, fixed ability and quick learning, are part of an implicit theory of intelligence. This is a possible reason why the subset of “learning is quick” was also loaded on innate learning. Although these factors are probably related to beliefs of epistemology, they are different constructs and should be separated. Therefore, Hofer and Pintrich introduced a model of personal epistemology only concerning the nature of knowledge and knowing. The nature of knowledge includes certainty of knowledge (from absolute to contextual to relativism) and simplicity of knowledge (from simple to complex). The nature of knowing includes the source of knowledge (from reliance on authority to self construction) and the justification for knowing (acceptance of facts to critical reevaluation of expertise and context). Although this model proposed by Hofer and Pintrich is cited widely in the literature, the model is under-implemented and under-tested.

Due to methodological limitations of the unidimensional model, Schommer’s work has attracted a great deal of attention from researchers in this field. Several studies have applied this idea by either improving Schommer’s instrument or developing new instruments in order to serve their particular needs. The following section presents diverse instruments and provides comparisons of their validity and reliability. For the purpose of this dissertation, only English instruments are reviewed. The discussion also does not include those domain-specific instruments, such as internet-specific epistemic beliefs (Bråten et al., 2005) or the beliefs specifically related to mathematics and history (Buehl & Alexander, 2005).

Schommer’s epistemological questionnaire (EQ).

Based on Perry’s (1968) and Ryan’s (1984) work, Schommer developed the epistemological questionnaire with 12 subsets and 63 items for five dimensions: simple knowledge, certain knowledge, omniscient authority, innate ability, and quick learning. Simple

knowledge had two subsets, seek single answers and avoid integration; certain knowledge included two subsets, avoid ambiguity and knowledge is certain; omniscient authority included two subsets, don't criticize authority and depend on authority; innate ability had three subsets, can't learn how to learn, success is unrelated to hard work, and ability to learn is innate; and quick learning had three subsets, learning is quick, learn first time, and concentrated effort is a waste of time. The questionnaire included 28 negative items and 35 positive items. Students rated their degree of agreement with each statement on a scale from 1 (strongly disagree) to 5 (strongly agree). Schommer (1990) conducted an exploratory factor analysis of the 12 subsets with a principal factoring extraction and orthogonal varimax rotation. The four factors, excluding omniscient authority, emerged and accounted for 55.2 percent of the variance. An eigenvalue greater than one is a cutoff point for factors, and a factor loading greater than .5 is a criteria for selecting items.

However, in Schommer and her colleagues' replication study (Schommer, Crouse, & Rhodes, 1992), they did not obtain a similar structure. They conducted the research with similar subjects and only successfully extracted 3 factors. Next, they forced a 4-factor structure, which resulted in similar results; however, the subsets within each factor were somewhat different. First, the label of innate ability was changed to externally controlled learning, since the subset of "learn first time" was not loaded and "concentrated effort is a waste of time" was loaded. Second, the subset of "depend on authority" was not loaded on any factors in 1990, but it was loaded on the factor of simple knowledge in 1992. Third, both "don't criticize authority" and "knowledge is certain" were loaded on the factor of certain knowledge, but only "knowledge is certain" was loaded in 1990. According to confirmatory factor analysis, they compared the 3-factor structure that they first extracted from the 1992 work and the 4-factor structure from 1990

work. They concluded that the 4-factor structure has a better fit, based on goodness-of-fit index, adjusted goodness-of-fit, and chi-square.

In addition to college students, Schommer and her colleagues (Schommer, 1993; Schommer, Calvert, Gariglietti, & Bajaj, 1997) also modified the questionnaire for secondary students. For example, they changed the word “theory” to “idea.” They found a similar 4-factor structure also existed for high school students. Epistemic beliefs accounted for learning performance through both the cross-sectional study (Schommer, 1993) and the longitudinal study (Schommer et al., 1997). They concluded that students in higher grades had more sophisticated beliefs and girls were less likely to believe in quick learning and fixed ability.

Schommer-Aikins, Brookhart, and Hutter (2000) further extended the use of the epistemological questionnaire to 7th and 8th grade middle school students. Based on her work in 1990, 31 items were used in the 4-factor structure. They piloted these 31 questions to middle school students and concluded a 30-item epistemological questionnaire on the basis of their screening process. Confirmatory factor analysis applied to a random half of the sample concluded that the four-factor structure was not a good fit, so the researchers removed items with small factor loadings and a small correlation with other items within factors. This refinement resulted in a 3-factor structure with stability of knowledge, speed of learning, and ability to learn. In 2005, Schommer-Aikins, Duell, and Hutter again used the same 30 items with middle school students. They conducted an exploratory factor analysis; the extract method was not specified. Based on the analysis and a scree plot, they found a 4-factor structure which was different from the structure they concluded in 2000. The new 4-factor structure included two old factors, quick learning and certain knowledge, and two new labels, studying aimlessly and omniscient

authority. These two studies indicated that students' beliefs in learning were related to their GPA and their domain-specific epistemic beliefs.

Schommer's epistemological questionnaire was validated for different educational levels. It is currently the most prevailing instrument of epistemic beliefs and is utilized for diverse purposes. However, some problems regarding the instrument and item validity as well as instrument reliability had been indicated in other studies. The issues include a low internal consistency within factors (Debacker, Crowson, Beesley, Thoma, & Hestevold, 2008), vague remnants of personality measurement with questionable relevance to indicators of beliefs about knowledge, and inconsistency of phrasing of items (e.g., first-person, second-person, and third-person format) (Hofer & Pintrich, 1997).

Jehng et al.'s epistemological questionnaire (JEQ).

Based on Schommer's framework, Jehng, Johnson, and Anderson (1993) developed a new instrument, comprising five factors: certainty of knowledge, omniscient authority, orderly process, innate ability, and quick learning. The simple knowledge in Schommer's work was replaced by *Orderly Process*, which was defined as "the learning process [that] tends to be regular rather than irregular" (p. 26, Jehng et al., 1993). Twenty-seven students participated in their pilot study and were required to rate whether each statement was understandable. They also validated the content validity of the scale through a panel discussion with three university faculty members. The questionnaire resulted in 51 items through these two steps.

They first conducted Cronbach's α reliability and eliminated 10 items with a coefficient smaller than .1, which indicated that those items were inconsistent with others and they might decrease the entire reliability of the instrument. Then they conducted a discrimination power which indicated that seven items had low discrimination capability. As a result, 34 items were

used for final analysis. According to the results from LISREL analysis, also known as confirmatory factor analysis (CFA), they concluded that the findings supported a multidimensional characteristic of epistemic beliefs. The criteria they used for deciding whether the model was good were not reported.

In addition, they used this questionnaire to compare students from different disciplines and different academic levels through MANOVA. Students in the arts and social sciences were more likely than business and engineering students to believe that knowledge is uncertain, knowledge is best acquired from independent reasoning, and learning is not an orderly process. Graduate students were more likely than undergraduates to believe that knowledge is uncertain, knowledge is best acquired from independent reasoning, and learning is not an orderly process.

Schraw et al.'s epistemic belief inventory (EBI).

Schraw, Dunkle, and Bendixen (1995) modified Schommer's questionnaire and developed a new instrument with five dimensions of epistemic beliefs, including certain knowledge, simple knowledge, omniscient authority, quick learning, and fixed ability. They indicated several theoretical and methodological issues and challenges for applying Schommer's questionnaire (Schraw, Bendixen, & Dunkle, 2002). One issue was that Schommer had difficulty identifying one of the important hypothesized factors, namely, omniscient authority; however, the factor was observed in all five unidimensional models. Additionally, there were 63 items in Schommer's questionnaire and 51 items in Jehng et al.'s questionnaire. The long instrument may have easily exhausted respondents and further influenced the reliability of their responses. The goal of the new questionnaire was to overcome these two issues and create a shorter but still complete set of epistemic beliefs.

This inventory contains 32 items, including 26 new items and 6 items reworded from Schommer's (1990) items. From the exploratory factor analysis, they successfully extracted five factors, including simple knowledge, certain knowledge, omniscient authority, fixed ability, and quick learning. These factors all have an eigenvalue over one. According to factor loadings, they selected those items with loadings over .3 and cross-loading smaller than .3; this resulted in 16 items for their later analysis of the relationships between epistemic beliefs and performance on well-defined and ill-defined problems. They concluded that epistemic beliefs were related to performance on the ill-defined tasks but not the well-defined tasks.

Hofer's discipline-focused epistemological beliefs questionnaire (DEBQ).

In Hofer and Pintrich's (1997) extensive reviews on models of personal epistemology, they concluded that beliefs of learning and intelligence do not seem to be comprised within the personal epistemology model. Details are discussed on page 34 to 36. They proposed that only four dimensions should be contained in the model, including certainty of knowledge, simplicity of knowledge, source of knowledge, and justification for knowing. Separating these beliefs from both the domain-general and domain-specific measurement of epistemic beliefs may provide clarification to the research and theories in the field. Following this conclusion, Hofer (2000) developed the discipline-focused epistemological beliefs questionnaire. This questionnaire encompassed new items created by Hofer and items that were adapted from Perry's checklist of educational values and Schommer's EQ.

The questionnaire included 27 items with a 5-point scale. Principal components and maximum likelihood factoring of items with varimax rotation were conducted. Four factors were extracted meaningfully: *comprising certain/simple knowledge; justification for knowing: personal; source of knowledge: authority; and attainability of truth*. Certain and simple

knowledge do not result in two separate factors, as in Schommer's (1990) and Jehng et al.'s (1993) findings; however, this finding is consistent with Qian and Alvermann (1995). Additionally, Hofer created two labels with more narrow definitions. First, *justification for knowing: personal* represents that knowing is justified by individual opinion or firsthand experience. Because the factor does not comprise other ways for justification, such as evaluation of evidence or assessment of expert opinion, Hofer highlighted the characteristic of *personal* in the label. Second, *source of knowledge: authority* refers to expert knowledge, texts, and other external authority as the source of knowledge. Because the factor does not comprise other sources, such as individual construction of meaning, she labeled *authority* in the factor. Concerning the last factor, *attainability of truth*, Hofer (2000) contended it did not usually emerge as a single factor in other studies. She suggested that future research is required to see how consistently this factor appears. The factor was later found in the study of Wood and Kardash (2002).

Wood and Kardash's epistemological beliefs survey (EBS).

In Wood and Kardash's (2002) discussion of measurement issues, they reported that Schommer's questionnaire always analyzed using the 12 subsets rather than the 63 items as variables. This level of analysis added variability to each factor. Additionally, these subsets did not consistently load on the four factors that they extracted and some subsets cross-loaded on other factors. For instance, "Avoid ambiguity" was hypothesized as a subset for certain knowledge, but it was loaded on simple knowledge instead (Schommer, 1990). The factor of "Omniscient authority" consistently did not emerge as one factor, and it appeared to load on simple knowledge in 1992. Jehng et al. (1993) also did not analyze how the complete 51 items loaded on the five factors that they hypothesized.

For these reasons, Wood and Kardash (2002) combined Schommer's and Jehng's questionnaires and attempted to see how these 80 items loaded on factors from the empirical data. Duplicate items were removed. They found similar patterns using maximum likelihood, principal components, and by generalizing the least squared extractions with a promax rotation. Maximum likelihood extraction with varimax, oblimin, quartimax, and promax rotations also yielded the same general pattern of loadings.

They concluded that the best fit was a five-factor structure, comprising speed of knowledge acquisition, structure of knowledge, knowledge construction and modification, characteristics of successful students, and attainability of truth. *Speed of knowledge acquisition* indicates that learning is a quick or gradual process. *Structure of knowledge* indicates that knowledge is either discrete and unambiguous or complex and interrelated. Low scores of *knowledge construction and modification* represent that knowledge is certain, passively received, and accepted without questioning; high scores represent that knowledge is constantly evolving, actively constructed, and questionable. *Characteristics of successful students* represent that learning is either innate or takes time and effort. This factor includes items from orderly process and quick learning and innate learning. *Attainability of truth* indicates an objective truth that can be known or a rejection of the notions of objective truth—which was also found in Hofer's (2000) questionnaire. They also conducted t-test to gauge the differences in epistemic beliefs between males and females. The results indicated that there are some differences between the genders in undergraduate students; however, male and female graduate students did not differ on any of the five factors.

Comparison across different questionnaires.

As reviewed earlier, there are several questionnaires for multidimensional measurement of personal epistemology; therefore, the next question would be how to select an instrument and whether or not a better instrument exists. As a result, several scholars conducted comparison studies in order to determine a more reliable and valid questionnaire.

First, Schraw et al. (2002) compared their EBI with Schommer's EQ. One hundred sixty undergraduates participated in the study and completed both the EQ and the EBI. They conducted different extraction and rotation methods, and found that different combinations resulted in similar factor structures. Five factors were reported for EQ, including integrative thinking, incremental learning, certain knowledge 1, certain knowledge 2, and innate ability. Certain knowledge 1 represents accessibility to certain knowledge, e.g., "Scientists will ultimately discover truths." Certain knowledge 2 represents the degree to which certain knowledge exists. Integrative thinking, the new factor, represents that thinking is integrative and original.

The EBI resulted in five different factors, comprising omniscient authority, certain knowledge, quick learning, simple knowledge, and innate ability, which had been commonly extracted in other studies. Schraw et al. (2002) found that the EBI explained more sample variations than EQ. None of the EQ factors was significantly correlated with reading comprehension scores, but EBI factors were significantly correlated with the scores. The finding suggested that the construct validity of EQ was troublesome. However, both questionnaires had low internal consistency, as confirmed by Debacker et al. (2008). Interestingly, these two questionnaires did not seem to measure personal epistemology in the same fashion, although the labels were similar. Correlation coefficients of the nine factors extracted by the two instruments

were low, except for certain knowledge one in EQ versus certain knowledge in EBI and integrative thinking in EQ versus quick learning in EBI. The results indicated that EBI and EQ both tapped the same certain knowledge dimension. Integrative thinking was also negatively correlated to quick learning, which implies that quick learning may impede deeper learning.

Another study done by Debacker et al. (2008) compared EQ, EBS, and EBI. These three instruments are all domain-general and based on the factor structure proposed by Schommer (1990). They first conducted a confirmatory factor analysis of EBI and EBS to evaluate whether these items fit the proposed factor structures. For EQ, in order to extract a reasonable factor structure, they conducted a principal axis factoring analysis of both subsets and items, and then conducted CFA.

Debacker et al. (2008) found that their EBI data did not fit the theoretical model that Schraw et al. (1995) had proposed. Factors regarding beliefs about knowledge (i.e. simple knowledge, certain knowledge, and omniscient authority) had higher correlations with each other, and so did beliefs about learning (i.e. quick learning and innate ability). Compared with EBS, EBI had worse fit statistics and internal consistency, but less interrelatedness among factors. When excluding those items with low loadings ($<.35$) in EBI and EBS, both of the fit statistics improved. Additionally, they also failed to generate the same factor structure as Schommer's (1990). They only found two meaningful factors, belief in simple knowledge and fixed ability, through analysis of 12 subsets. It is notable that they could not yield a similar structure when conducting a factor analysis of Schommer's complete 63 items. The fit statistics for EQ were better than for EBS or EBI; however, the numbers were not comparable. The EQ factors in Debacker et al.'s (2008) study were different from the items and the structure proposed by Schommer, since Debacker et al. removed items through the factor analysis.

Debacker et al. (2008) recommended EBI and EBS over EQ, based on the following reasons. Regarding the use of EQ, sample-specific scoring and their failure of capturing the theoretical factor structure provided evidence of psychometric problems. A factor structure can be different for each new sample. As a result, each study actually uses a different structure to measure the same construct. Their concern also raises the problem of comparing findings across studies, even though studies use the same instrument.

In general, the internal consistency for these three instruments was poor. The reliability for most factors was below .7. The more reliable factors they found were all related to learning or intelligence, including beliefs in fixed ability and speed of knowledge acquisition. EBS had better factors of the structure of knowledge and knowledge construction and modification, but the Cronbach alphas coefficients were still low. Debacker et al. (2008) suggested that a more domain- or context-specific instrument of epistemic beliefs might yield higher internal consistency.

Summary.

Schommer's questionnaire is the most widely used epistemic beliefs instrument and has been adjusted for different contexts, including middle school students, high school students, and students in higher education. However, as aforementioned, there are diverse theoretical issues (Hofer & Pintrich, 1997) and problems about the construct and item validity and reliability (Hofer & Pintrich, 1997; Debacker et al., 2008; Schraw et al., 1995). Although consistent factors have been identified in the research, there are variations with regard to the number of identified factors and the nature of the beliefs.

Hofer and Pintrich (1997) extensively reviewed the construct of epistemic beliefs and criticized that factors of beliefs in intelligence, learning, and instruction should be removed from

instruments of epistemic beliefs. Extensive discussion is presented in is presented in the section on Schommer's multidimensional models. Although which theoretical model is more accurate is still an open issue for empirical investigation, Hofer's questionnaire was preferable to other questionnaires (e.g. Schommer's EQ, Jehng's JEQ, or EBI) for the following reasons.

First, separating beliefs about knowledge from beliefs about learning could provide clarification to the research and theorizing in the field. Focusing on beliefs in knowledge and knowing might particularly be more beneficial for understanding online sharing behaviors. Bråten and Strømsø (2006) found beliefs about knowledge and knowing were explanatory variables for online communication preference, but did not find the same relationship between beliefs about learning and that preference. Their findings are further discussed in the next section. Since the relationships between epistemic beliefs and individuals' contributions to online communities were of interest, beliefs about knowledge and knowing were the focus of this current research.

In addition, since participants in this study were adults participating in online communities of practice, Hofer's DEBQ was more suitable for the context of this current research. Schommer-Aikins (2002) pointed out that children were less able to differentiate beliefs about knowledge from beliefs about learning. Adults might be more capable of differentiating the two beliefs than children.

Second, a domain-specific questionnaire was preferable. Many of the current instruments were domain-general in nature, such as Shommer's EQ and Jehng's JEQ. DeBacker et al. (2008) found that the domain-general questionnaires had a more serious problem with internal consistency. They suggested that a more context-specific questionnaire, like Hofer's DEBQ, might yield higher internal consistency. In addition, Shommer-Aikins (2002) highlighted that

domain-specific epistemic beliefs would become more and more important as an individual develops. Children's epistemic beliefs tend to be domain-general. When an individual gains more experience in domains of interest, he begins to develop domain-specific epistemic beliefs, which may deviate from domain-general epistemic beliefs developed during his childhood (Schommer-Aikins, Duell, & Barker, 2003). For participants in this current research, adults in online communities of practice, domain-focused epistemic beliefs were conceivably more important than domain-general beliefs. Consequently, it made sense to distribute a domain-focused questionnaire.

Third, considering the data collection process of this study, it was more appropriate to adopt a short questionnaire. Typically, the measurements of epistemic beliefs have had a large number of items (e.g., 64 items in Schommer's EQ and 51 items in Jehng et al.'s JEQ). A long questionnaire might easily exhaust respondents and reduce their willingness to complete the entire questionnaire. While this might not be a problem in a setting where survey completion is required (e.g. a school or university class), it was considered a potential threat in this context, as survey participation was voluntary and completion of all questions could not be mandated.

Finally, compared with other questionnaires, Hofer's questionnaire was easier to adapt to design-focused epistemic beliefs. Items regarding beliefs in learning and instruction from other models were mainly focused on school settings, such as "Students who are mediocre in high school will remain mediocre in college" (Jehng, 1991). These items were harder to modify to design-focused items. For these four reasons, Hofer's DEBQ was selected.

In summary, the multidimensional models and associated instruments attracted a great deal of attention. Researchers in the field extensively explored the relationship between epistemic beliefs and variables other than age and gender. Previous studies have explored the

effects of epistemic beliefs on learning performance (Schommer et al., 1992; Schommer, 1993) as well as learning strategy (Schommer et al., 1992; Schommer-Aikins et al., 2005), reasoning (Schommer, 1990), and ill-structured problem solving (Schraw et al., 1995). However, validity of these studies is limited by audience. Furthermore, differences of epistemic beliefs in different disciplines were confirmed in various studies, both within an individual (Hofer, 2000) and among individuals in different domains (Jehng et al., 1993). As suggested in Buehl (2008), researchers should continue to explore how beliefs about knowledge emerge and how beliefs are related to formal and informal education experiences. Table 3 presents a summary of multidimensional measurements and findings which are based on a review framework by Buehl (2008).

Table 3

Summary of Multidimensional Measurements

Author(s), Year n/Ed. Level	Based Instrument: Details and Format	Analysis	Extracted Factors (Cronbach alphas)	Relationships with other variables
Schommer, 1990 263/Ungrd	Origin of epistemological questionnaire (EQ) <ul style="list-style-type: none"> 63 items, 12 subsets 5-point scale 15-20 mins to administer Five hypothesized factors <ul style="list-style-type: none"> Simple knowledge Certain knowledge Omniscient authority Innate ability Quick learning 	EFA <ul style="list-style-type: none"> Principal factor analysis of 12 subsets Varimax rotation Extraction- λ(Eigenvalue) > 1 Item selection- loadings > .5 55.2 percent of variance explained 	<ul style="list-style-type: none"> Simple knowledge Certain knowledge Innate ability Quick learning 	<ul style="list-style-type: none"> Home and educational background affect epistemic beliefs. Quick learning explains oversimplified conclusions, poor performance, and overconfidence in test. Certain knowledge explains inappropriately absolute conclusions.
Schommer, Crouse, & Rhodes 1992 424/Ungrd	EQ <ul style="list-style-type: none"> 63 items 5-point scale 15-20 mins to administer 5 assumed factors 	EFA <ul style="list-style-type: none"> Principal factor analysis of 12 subsets Varimax rotation Extraction- λ > 1 results in 3 factors and λ > .95 results in 4 factors. Item selection- loadings N/A 54.2 percent of variance explained CFA <ul style="list-style-type: none"> Compared the 4-factor structure from Schommer (1990) to 3-factor structure from this study 3 factors: GFI=.911; AGFI=.864 4 factors: GFI=.938; AGFI=.899 	<ul style="list-style-type: none"> The 4-factor structure from this data was different from the 4-factor structure from Schommer (1990). CFA suggested that 4-factor model from Schommer (1990) provided the best fit of the data 	<ul style="list-style-type: none"> Belief in simple knowledge explains learning performance and comprehension in a math passage. Study strategies mediate belief in simple knowledge and performance.
Schommer, 1993 1182/Secondary Students	EQ <ul style="list-style-type: none"> Minor changes of Schommer (1990) Number of items: N/A 5-point scale 15-20 mins to administer 	EFA <ul style="list-style-type: none"> Principal factor analysis of 12 subsets Varimax rotation Extraction- λ > .98 Item selection- loadings > .5 53.5 percent of variance explained 	<ul style="list-style-type: none"> Fixed ability Simple knowledge Quick learning Certain knowledge (Cronbach alphas ranges from .51 to .78.)	<ul style="list-style-type: none"> Differences in epistemic beliefs between genders and grades were found. Belief in simple knowledge, certain knowledge, and quick learning decreased across the school years. Fewer girls believed in quick learning and fixed ability. Less belief in quick learning explains higher GPA.

(continued)

Table 3 (continued)

Author(s), Year n/Ed. Level	Based Instrument: Details and Format	Analysis	Extracted Factors (Cronbach alphas)	Relationships with other variables
Schommer-Aikins, Brookhart, & Hutter, 2000 1269/ Middle school students	EQ <ul style="list-style-type: none"> Modified to have fewer items and simpler expression 30 items 5-point scale 15-20 mins to administer Four hypothesized factors <ul style="list-style-type: none"> Ability to learn Speed of learning Stability of knowledge Structure of knowledge 	CFA <ul style="list-style-type: none"> Factor analysis of 30 items 4 factors: GFI=.87; CFI=.67; $\chi^2/df = 2.91$; RMR=.088 3 factors: GFI=.982; CFI=.978; $\chi^2/df = 1.61$; RMR=.038 	<ul style="list-style-type: none"> The four hypothesized factors did not result in a good fit, so they deleted items with small factor loadings and without correlation with other items The new model resulted in three factors: stability of knowledge, speed of learning, and ability to learning 	<ul style="list-style-type: none"> Students who believed in more gradual learning and incremental ability had higher GPA. No significant difference was found between genders.
Schommer-Aikins, Duell, & Hutter, 2005 1269/ Middle school students	EQ <ul style="list-style-type: none"> 30 items from their study in 2000. 5-point scale 15-20 mins to administer 	EFA <ul style="list-style-type: none"> Three steps of analysis: <ol style="list-style-type: none"> Conduct factor analysis of 30 items. Use varimax rotation and scree plot to decide number of factors that they are going to extract. Conduct factor analysis of 30 items to extract 4 factors. Conduct factor analysis of 21 items that had high loadings in step two (Loadings > .3). 40.35 percent of variance explained 	<ul style="list-style-type: none"> Quick learning (.77) Studying aimlessly (.55) Omniscient authority (.55) Certain knowledge (.36) 	<ul style="list-style-type: none"> Beliefs in quick learning and studying aimlessly were related to beliefs about math and math confidence. Both general and domain-specific epistemic beliefs explain students' GPA.
Jehng, Johnson, & Anderson, 1993 385/ Ungrad & Grad	Origin of Jehng et al.'s Epistemological Questionnaire (JEQ) <ul style="list-style-type: none"> 60 items for the pretest 51 items for the final version 7-point scale Five hypothesized factors <ul style="list-style-type: none"> Certainty of knowledge Omniscient authority Orderly process Innate ability Quick learning 	Eliminate items through Cronbach α (<.1) and low discrimination power. CFA <ul style="list-style-type: none"> 34 items were left for the later analysis. LISREL Test 5-factor model for 34 items $\chi^2 (517)=571.44$ GFI=.929 	<ul style="list-style-type: none"> The same five factors (.42-.59) 	<ul style="list-style-type: none"> Scores on each dimension were computed by the average rating for all of the items loading on the particular factor. MANOVA <ul style="list-style-type: none"> Comparing with undergraduates and students in business as well as engineering, graduate students and social science and art students were more likely to believe that knowledge is uncertain, knowledge is best acquired from independent reasoning, and learning is not an orderly process.

(continued)

Table 3 (continued)

Author(s), Year n/Ed. Level	Based Instrument: Details and Format	Analysis	Extracted Factors (Cronbach alphas)	Relationships with other variables
Schraw, Dunkle, & Bendixen, 1995 I: 212/ Ungrad II: 124/ Ungrad	Origin of Schraw et al.'s Epistemic Belief Inventory (EBI) <ul style="list-style-type: none"> 32 items (26 items were new, and 6 items were reworded from items developed by Schommer (1990). 5-point scale Five hypothesized factors <ul style="list-style-type: none"> Simple knowledge Certain knowledge Omniscient authority Fixed ability Quick learning 	EFA <ul style="list-style-type: none"> Principal factor analysis of 32 items Oblique rotation and varimax conducted, and varimax reported Extraction- $\lambda > 1$ Item selection- loadings $> .3$ and cross-loading $< .3$ 16 items were left. Study I: 64 percent of variance explained Study II: 60 percent of variance explained 	<ul style="list-style-type: none"> The same five-factor structure as hypothesized 	<ul style="list-style-type: none"> Scores on each dimension were computed by the average rating for all of the items loading on the particular factor. Regression <ul style="list-style-type: none"> Quick learning was a significant explanatory variable of well-defined problem solving. Discriminant Analyses <ul style="list-style-type: none"> Determine which factors of epistemic beliefs discriminated four levels of relativism. Epistemic beliefs were related to performance on the ill-defined tasks but not well-defined tasks.
Wood & Kardash, 2002 793/Ungrad & Grad	Combine EQ and JEQ <ul style="list-style-type: none"> 80 items (58 items from EQ and 22 items from JEQ) 5-point scale 	Eliminate items through inter-item correlation $< .1$. Sixty-four items were left. EFA <ul style="list-style-type: none"> Principle axis factor of items Promax rotation Extraction- $\lambda > 1$ and scree plot 22.05 percent of variance explained Item selection- loadings $> .35$ and cross-loading $< .25$ 38 items were left for later analysis 	<ul style="list-style-type: none"> Speed of knowledge acquisition (.74) Structure of knowledge (.72) Knowledge construction and modification (.66) Characteristics of successful students (.58) Attainability of objective truth (.54) 	<ul style="list-style-type: none"> Scores on each dimension were computed by the average rating for all of the items loading on the particular factor. T-test <ul style="list-style-type: none"> There are some differences between genders for undergraduate students. However, male and female graduate students did not differ on all five factors.
Hofer, 2000 326/Ungrad	Origin of Hofer's DEBQ <ul style="list-style-type: none"> 27 items 5-point scale Administered separately for knowledge in psychology and in science. Four hypothesized factors: <ul style="list-style-type: none"> Certainty of Knowledge Simplicity of Knowledge Source of Knowledge Justification for Knowing 	EFA <ul style="list-style-type: none"> Principle component analysis and maximum likelihood factoring of items Varimax rotation Extraction- $\lambda > 1$ and scree plot Item selection- loadings $> .4$ (except one item = .32) 18 items were left. Psychology: 46.09 percent of variance explained Science: 53.14 percent of variance explained 	<ul style="list-style-type: none"> Certain/ simple knowledge (.74 in psychology/.81 in science) Justification for knowing: personal (.56/.61) Source of knowledge: authority (.51/.64) Attainability of truth (.60/.75) 	Strong disciplinary differences were found within an individual. <ul style="list-style-type: none"> Compared with knowledge in psychology, knowledge in science is more certain and unchanging. For science, students were more likely to regard authority and experts as the source of knowledge, more likely to believe truth is attainable by experts, and less likely to regard personal knowledge and firsthand experience as a basis for justification.

(continued)

Table 3 (continued)

Author(s), Year n/Ed. Level	Based Instrument: Details and Format	Analysis	Extracted Factors (Cronbach alphas)	Relationships with other variables
Schraw, Bendixen, & Dunkle, 2002 160/Ungrd	EBI & EQ <ul style="list-style-type: none"> 28 items from EBI and 63 items from EQ Administer EQ first and then EBI 	EFA <ul style="list-style-type: none"> Principal factor analysis of items Conduct oblique rotation and varimax rotation Varimax rotation was reported. EQ <ul style="list-style-type: none"> 35 percent of variance explained Item selection- loadings > .3 EBI <ul style="list-style-type: none"> 60 percent of variance explained Item selection- loadings > .3 None cross-loadings >.3 	EQ <ul style="list-style-type: none"> Integrative thinking (.61) Incremental learning (.64) Certain knowledge-1 (.74) Certain knowledge-2 (.53) Innate ability (.74) EBI <ul style="list-style-type: none"> Omniscient authority (.68) Certain knowledge (.62) Quick learning (.58) Simple knowledge (.62) Innate ability (.62) 	<ul style="list-style-type: none"> EBI explained more sample variation than EQ. Internal consistency coefficients are all low. In general, EQ factors were uncorrelated with EBI factors, except certain knowledge versus certain knowledge 1 and quick learning versus integrative thinking. EBI had stronger correlations to reading comprehension than EQ.
DeBacker, Crowson, Beesley, Thoma, &Hestevold, 2008 I: 795/Ungrd II: 795/ Ungrd II: 935/ Ungrd	EQ, EBI, and EBS I: EBI <ul style="list-style-type: none"> Five hypothesized factors: Simple knowledge, certain knowledge, quick learning, fixed learning, and omniscient authorities II: EBS <ul style="list-style-type: none"> Received a packet of surveys and completed at home Five hypothesized factors: speed of knowledge acquisition, structure of knowledge, knowledge construction and modification, characteristics of successful students, and attainability of objective truth. III:EQ <ul style="list-style-type: none"> Received a packet of surveys and completed at home 	I: CFA using LISREL <ul style="list-style-type: none"> Sample 1: CFI=.79, GFI=.85, AGFI=.8 Sample 2: CFI=.83, GFI=.85, AGFI=.83 Exclude the 11 items, Sample 1: CFI=.89, GFI=.91, AGFI=.88, RMSEA=.06 Exclude the 11 items, Sample 2: CFI=.91, GFI=.91, AGFI=.89, RMSEA=.053 II: CFA using LISREL <ul style="list-style-type: none"> Sample 1: CFI=.9, GFI=.85, AGFI=.83, RMSEA=.05 Sample 2: CFI=.88, GFI=.85, AGFI=.83, RMSEA=.052 Exclude the 9 items, Sample 1: CFI=.92, GFI=.88, AGFI=.86, RMSEA=.052 Exclude the 9 items, Sample 2: CFI=.89, GFI=.87, AGFI=.85, RMSEA=.059 III <ul style="list-style-type: none"> 1. EFA of subsets <ul style="list-style-type: none"> Principal axis factoring with varimax rotation Extraction- $\lambda > 1$ Item selection- loadings > .35 Six subsets loaded on two factors 26.74 percent of variance explained 2. EFA of 63 items <ul style="list-style-type: none"> Did not result in a meaningful structure 3. CFA of the 2-factor structure created in step 4. CFI=.97, GFI=.99, AGFI=.97, RMSEA=.045 	III: EFA of subsets <ul style="list-style-type: none"> Belief in simple knowledge: avoid ambiguity, seek single answers, and avoid integration Belief in fixed ability: cannot learn how to learn, learn the first time, and success unrelated to hard work 	They failed to generate the same factor structure as Schommer's (1990). Fit statistics: EQ>EBS>EBI Internal consistency: EBS>EBI>EQ (They were all low.) Interrelatedness: EBS>EBI

Domain Specificity and Epistemic Beliefs

The reviews of previous models lead to the discussion of domain specificity. Whether epistemic beliefs are different across domains and disciplines is explored. The construct is better understood through domain-general, domain-focused, or domain-specific models.

There has been a trend in the study of epistemic beliefs to shift from a domain-general (Baxter Magolda, 1992; King & Kitchener, 1994; Perry, 1970) to a domain-specific assumption. Meanings of domains are usually interchangeable throughout academic disciplines (Hofer & Pintrich, 1997). Alexander (1992) characterized a domain as a particular field of study, comprising declarative, procedural, and conditional knowing. Hofer (2006) indicated that domains should also include knowledge beyond the academic realm.

Several studies concluded differences of epistemic belief in various domains and disciplines, but one study identified the characteristics of domain generality. Schommer and her colleagues found domain-general beliefs between math and social science (Schommer & Walker, 1995). On the contrary, a series of later studies done by Schommer and her colleagues concluded the existence of both domain generality and specificity in math, social sciences, and business (Schommer-Aikins, Duell, & Barker, 2003; Schommer-Aikins et al., 2005). Juhng et al. (1993) also found differences between social science/art (soft fields) and business/engineering (hard fields). Buehl and her colleagues found both domain-general and domain-specific epistemic beliefs in history (ill-structured domains) and mathematics (well-structured domains) (Buehl, Alexander, Murphy, 2002). Her later research also indicated a consistency in the sophistication of epistemic beliefs across the two domains (Buehl, et al., 2004). Hofer (2000) found that an individual could hold different epistemic beliefs in psychology and science. Epistemic beliefs

within individuals could be activated in a given context but not in another context; the beliefs might be context-sensitive in one context but remain stable in another context.

A combination model that was both domain-general and domain-specific in nature was proposed by several researchers (Buehl & Alexander, 2001; Muis et al., 2006). Buehl and Alexander introduced a nested model with three levels of belief: general epistemic beliefs at a broad layer, domain-specific beliefs (e.g., beliefs about psychology knowledge), and general beliefs about academic knowledge. This model was extended by Muis et al. (2006) and emphasized the development of epistemic beliefs over time in a socio-cultural context.

In terms of the development of instruments and items, Hofer (2005) identified three different types of instruments in the field: (a) domain-general questionnaires (e.g., EQ, JEQ, etc.), (b) domain-focused questionnaires (e.g., Buehl et al., 2002; Hofer, 2000), and (c) domain-specific questionnaires (e.g., Elder, 2002). The second type has similar statements to domain-general questionnaires, but respondents are required to refer to the domain (e.g., psychology) while answering the questions. Items in the third type of questionnaire specifically pinpoint a domain and include particular ways of knowing the domain, such as an experimental method for knowing science.

Epistemic Beliefs and Participation in Online Activities and Online Communities

As discussed earlier, personal epistemology involves understanding personal beliefs about the nature of knowledge and knowing. The construct plays an even more important role when learning takes place within an online environment. Learners within an online learning environment require a self-regulated and self-directed process. Online learners, especially adults, have the power to decide *who* can instruct them, *why* they need to learn, *what* they want to learn,

where they should stay while learning, *when* they should learn, and *how* to learn effectively and efficiently. Characteristics of online information are also different from traditional sources of information. Information on the Web is enormous in volume and updates rapidly. Knowing how to filter useful and relatively accurate information becomes an important skill. These issues and the resulting decisions are all conceivably affected by an individual's beliefs about knowledge and knowing.

There are two diverse perspectives based on empirical studies of the relationship between epistemic beliefs and designs and effectiveness of online learning environments. First, studies of interest believe epistemic beliefs are related to the characteristics of an individual, and they explore how these beliefs influence the individual's online learning performance and behaviors. The purpose of these studies is to improve the designs of the online environments and enhance the individual's performance. Since this perspective is the focus of this dissertation, the following review presents related discussions, including that of online learning performance, designs of online learning environments, designs of online help environments, online searching and seeking information, and communication through an online system in relation to individuals' epistemic beliefs. Another perspective concerns how the design of online learning environments can improve individuals' development of epistemic beliefs. In other words, such studies use epistemic beliefs as dependent variables (e.g., Tsai, 2008). Since this is not the purpose of this current research, the following reviews accordingly exclude them.

Online learning performance.

When scholars in the field started observing epistemic beliefs in a new context, the question that they asked first concerned the impact of epistemic beliefs on an individual's online learning performance. Bendixen and Hartley (2003) found that beliefs in omniscient authority

and fixed ability were negatively related to learning achievement within online learning environments, which was consistent with the paper-based study from Schommer (1990). However, contrary to Schommer's (1990) findings, belief in quick learning was positively related to achievement. Bendixen and Hartley postulated that this was due to time limitations. Those participants only had 30 minutes to study a Geography instruction manual, so the belief actually facilitated those students to read through the material in a timely way.

With respect to ill-structured problem solving performance within online discussion environments, Oh and Jonassen (2007) provided a case scenario (e.g. a student with some problematic behaviors in school) in their research, and asked participants to analyze the case and to find an appropriate solution. They used EBI (Schraw et al., 1995) to understand individuals' epistemic beliefs. As expected, they found that belief in simple knowledge was negatively correlated with individual problem-solving performance. Individuals with a greater belief in simple knowledge were less likely to explore solution alternatives. However, contrary to previous studies (Bendixen & Hartley, 2003; Schommer, 1990), Oh and Jonassen found positive correlations among ill-structured problem-solving performance, belief in omniscient authority, and belief in fixed learning. However, they did not provide an explanation for this unexpected relationship.

Epistemic beliefs and designs of learning environments.

Regarding the designs of online environments, Jacobson and Spiro (1995) tested the effects of two different ways of structuring learning content: hypertext-like and linear-like online environments. Among individuals who had advanced epistemic beliefs, problem-solving essay scores were significantly higher in a more hypertext-like environment than in a simple, linear-like environment. Students with simple epistemic beliefs instead gained higher problem-solving

essay scores in a linear-like learning environment. Jacobson and Spiro concluded that students with simple epistemic beliefs might have difficulty with the nonlinear nature of the hypertext system.

Windschitl and Andre (1998) examined two other types of design: constructivist versus objectivist computer simulation environments. The constructivist design allowed students to play with the simulation to hypothesize about and test possible answers to 12 questions about the human cardiovascular system; the objectivist design included step-by-step cookbook instructions prescribed by the researchers that led to answers to the human cardiovascular system questions. They used Schommer's 63-item questionnaire and calculated the overall scores as an index of participants' personal epistemic beliefs. Individuals with more sophisticated epistemic beliefs received higher learning scores within the constructivist simulation environment; individuals with less advanced beliefs learned more within the objectivist environment.

Demetriadis et al. (2008) conducted an experiment to test the interaction between individuals' epistemic beliefs and a scaffolding design within a web-based learning environment to examine the effect of two factors on students' learning performance. The group with the scaffolding design received three extra questions that could guide students to think through problems. Their findings indicated that those with complex epistemic beliefs in the scaffolded group acquired higher scores on the conceptual knowledge test than those with simple epistemic beliefs. The individuals with more complex epistemic beliefs were more responsive to the scaffolding design and benefited more.

Epistemic beliefs and designs of online help environments.

As Aleven et al. (2003) has indicated, individuals usually do not use help systems effectively; help systems are either underused or overused. Epistemic beliefs are one of the major

factors that may influence an individual's use of a help system. They suggested that it is important to consider users' epistemic beliefs and characteristics of subject matter content when designing a system. Thus, users may more easily understand logic and features of the help system, and as a result use it more effectively. Instead of understanding epistemic beliefs as a developmental model, they identified the beliefs as an individual difference. The design of different types of help for different epistemic beliefs of individuals was proposed. Additionally, existing studies (Baxter Magolda, 1992; Kuhn, 2000; Wood & Kardash, 2002) found that gender, age, and education were not sufficient to explain the variability in epistemic beliefs. Aleven et al. (2003) also emphasized that expertise is more important than age and year in school with regards to the seeking of further resources. Less able individuals may tend to use help more often.

Bartholome, Stahl, Pieschol, and Bromme (2006) explored the efficiency of two types of help designs (context-sensitive help and glossary), and their interaction with personal epistemic beliefs. Context-sensitive help provides different help materials based on the context. They measured epistemic beliefs on a domain-specific level using 14 semantic differential scale items and extracted three factors: texture of knowledge (unstructured versus structured knowledge), variability of knowledge (static versus dynamic knowledge), and genesis of knowledge (detected versus constructed knowledge). Their findings indicated that individuals who believed that knowledge is unstructured used context-sensitive help more often than those who believed in certain and structured knowledge. Beliefs in the genesis of knowledge significantly impacted their task performance. In other words, those who believed that knowledge is created by self-construction and negotiation went down fewer misleading paths and made more correct decisions. Bartholome, Stahl, Pieschol, and Bromme (2006) concluded that individuals with

sophisticated beliefs might monitor their tasks closely and were more likely to notice contradictory information on a wrong path earlier.

Epistemic beliefs and online searching and seeking information.

Regarding the relationship between online searching and judgment of information, Hofer (2004) stated, “Students’ use of the Internet as a medium for learning involves a host of epistemological judgments that deserve more attention” (p. 51). Hofer (2004) found that all four dimensions proposed by herself and Pintrich (1997) were mentioned in students’ think-aloud protocols and retrospective interviews. As expected, students with less sophisticated epistemic beliefs were more likely to pursue the searching task in a brief and intuitive way, and they did not perceive a need for examining the credibility and accuracy of sources.

Mason and Boldrin (2008) also studied epistemic monitoring and judgment during online searching with three different groups of students: undergraduate, high school, and middle school. They found that spontaneous evaluation of the credibility of electronic resources exists at all grade levels, but that younger students were less likely to consider the authority of a source.

In order to examine the influence of an individual’s beliefs about knowledge gained from Internet content and knowing while using the Internet, Bråten, Strømsø, and Samuelstuen (2005) developed a measure of Internet-specific epistemic beliefs. These were based on Hofer and Pintrich’s (1997) theoretical model and included 36 items on a five-point Likert scale. Two factors, general Internet epistemology and justification for knowing, were found. High scores on general Internet epistemology represented the certainty and simplicity of Internet-based knowledge; high scores on justification for knowing represented that Internet-based knowledge could be accepted without critical evaluation. Compared with Internet self-efficacy beliefs, they reported that Internet-specific epistemic beliefs more consistently predicted self-report Internet-

search behavior. The self-reported Internet-search behavior included two perspectives: identification of relevant information and evaluation of the appropriateness of information. A sample item of identification of relevant information was “When I do my course work, I use web sites that are relevant to the topics I study” (p. 167); a sample item of evaluation of the appropriateness of information was “I have difficulty identifying important information when I use the Internet” (p. 166).

In 2006, they re-examined the relationship between self-reported Internet-search activities and domain-general epistemic beliefs using items adapted from the Schommer’s EQ (Bråten & Strømsø, 2006). They only tested two domain-general dimensions: beliefs about the speed of knowledge acquisition, and beliefs about knowledge construction and modification. Their findings indicated that only beliefs about the speed of knowledge acquisition had a correlation with the self-report Internet-search behavior. Students with beliefs of quick learning might not realize the great challenge involved in an information search, so they were more likely to report that they could proficiently perform search tasks on the Internet.

Whitmire (2003) explored the connection between epistemic beliefs and information-seeking behavior. Information-seeking behavior is characterized in six stages: task initiation (recognize a need for information), topic selection (identify and select the general topic to be investigated or the approach to be pursued), pre-focus exploration (investigate information on the general topic to extend personal understanding), focus formulation (form a focus from the information encountered), collection (gather information related to the focused topic), and presentation (complete the search and prepare to present or use the findings). Students’ levels of epistemic beliefs were assessed through interviews. A low level represented Perry’s Dualism; a medium level represented multiplicity; and a high level represented relativism and commitment

within relativism. At the topic selection stage, individuals with medium-low epistemic beliefs were less engaged in the process and more likely to allow their advisor to select a topic for them. On the contrary, medium-high or high epistemic believers tended to consult different people and refer to various resources during the topic selection and pre-focus exploration stages. They were more likely to use a variety of search techniques and perceived themselves as capable of evaluating information. These students with medium-high or high beliefs actively assessed the information that they gathered and rejected conflicting information, based on their knowledge and their recognition of authoritative sources as well as political biases in the field.

Epistemic beliefs and communication through an online system.

Bråten and his colleagues (2005) explored the relationship between Internet-specific epistemic beliefs and self-reported Internet communication preferences. Guidance, cooperation, and discussion activities and preference for Internet-based feedback and discussion were rated in the category of Internet communication preferences. For instance, “I would rather get feedback on my work face-to-face than on the Internet” (Bråten et al., 2005, p. 166). Compared with Internet self-efficacy beliefs, Internet-specific epistemic beliefs were a better explanatory variable for self-report Internet communication preferences.

In 2006, they re-examined Internet communication preferences and epistemic beliefs using items adapted from the Schommer’s domain-general EQ (Bråten & Strømsø, 2006). They concluded that beliefs about knowledge construction and modification were a significant factor in Internet communication preferences. The dimension of knowledge construction and modification ranged from the belief that knowledge is given and stable to the belief that knowledge is actively constructed and consistently evolving, which is related to certainty and source of knowledge. The students with less sophisticated beliefs in knowledge construction and

modification were less likely to report using the Internet for study-related communication purposes.

Hornik, Johnson, and Wu (2007) conducted a study to explore how an individual's communication, satisfaction, and engagement are influenced by the congruency or discrepancy of epistemic beliefs and technological support in online learning environments. Research participants were given definitions of three types of learning models: objectivist, constructivist, and collaborative models. They were required to respond to two questions using the three learning models: (a) what learning approach would be the most effective way for them to learn, (b) what learning approach did they feel the currently used course management system supported. If they answered the two questions differently, it was deemed that a discrepancy existed. Communication was defined by the number of read discussion posts, the number of original discussion posts, and the number of follow-up discussion posts. Findings supported the idea that when discrepancy exists between an individual's epistemic beliefs and perceptions of how the technology supports learning, that person's learning performance, satisfaction, and course communication were reduced. In other words, matching epistemic beliefs and the technical support of learning environments can enhance learning performance and course communication. However, there is a need to be cautious about generalizing and applying findings from Hornik et al. (2007), since they measured epistemic beliefs differently from those studies based on Schommer's EQ. Epistemic beliefs in their study were assessed based on students' responses to the question about the most effective way to learn. They defined epistemic beliefs as "learner perceptions about what is the most effective way of learning" (p. 27). Although their findings are intriguing, the implications for epistemic beliefs are limited.

Summary.

Previous research has indicated negative correlations between problem-solving performance, quick learning (Bendixen & Hartley, 2003), and simple knowledge (Oh & Jonassen, 2007). However, there is no consistent finding on omniscient authority and fixed learning (Bendixen & Hartley, 2003; Oh & Jonassen, 2007). In order to design an effective online learning environment, several scholars suggested it is necessary to design an environment based on users' epistemic beliefs. If the design is congruent with individuals' epistemic beliefs inherent in the subject matter, they may perform better, engage more, and learn more.

Regarding online searching and information-seeking behaviors, Schommer (1998) posited that individuals with stronger beliefs in simple and certain knowledge are likely to search for single answers. In contrast, those who believe in complex and tentative knowledge may search for complex answers and anticipate multiple solutions. They are also prone to flexible and thorough thinking. Hofer (2004) found that all four theorized factors (certainty, simplicity, source of knowledge, and justification for knowing) of epistemic beliefs were mentioned by her research participants while they thought aloud during their online search process. The beliefs influence how an individual pursues searching tasks and how an individual justifies the collected information. More sophisticated epistemic believers were more likely to consider different information sources, consult different people, and actively evaluate the information (Whitmire, 2003).

Concerning communication through an online system, there is a lack of research that addresses this topic. Bråten and Strømsø (2006) found that those who believed knowledge is constructed through the identification of new ideas and that the integration of information should be derived from multiple sources were more likely to report that they had used information

technology to discuss or communicate with others. This finding is important; however, the implication is limited, due to the self-report method they conducted. A question of interest is how to understand the influence of epistemic beliefs on individuals' decisions and actual behaviors related to the contribution of knowledge.

Chapter 3

Method

The purpose of this study was to explore the relationships among levels of expertise, epistemic beliefs, and knowledge contributions to online CoPs hosted by firms. In this chapter, the contexts of the studied community, the population surveyed, and the procedures, implementation protocol, and analyses of the survey are described.

Contexts of the Studied Community

The online CoP was hosted by a software firm that developed diverse consumer and professional products. The firm had approximately US\$3 billion in revenue and 7,000 employees worldwide in 2008. The studied online community included graphic designers and Web designers. In the community, various learning materials were provided by the firm in order to help users not only resolve technical problems but also improve their job skills by increasing their proficiency with the products. The materials included items such as featured articles from experts in the field of design, galleries showing selected experts' artwork, video tutorials with step-by-step procedural instructions, and problem-solving and troubleshooting documents. Each type of resource had different characteristics and afforded different levels of participation for community members. For instance, the audio and video content in video tutorials provided easier procedural knowledge than text-based content. Additionally, while community members were only able to rate videos, they were able to have deeper level of participation for text-based content that allowed users to provide open-ended text, such as sharing experiences about solving specific problems.

Documentation, a type of learning content provided by the firm, covered content for different levels of expertise. A table of contents was shown side by side with each content page. Technical writers employed by the firm created the documentation. At the bottom of each page, community members could comment on documentation pages. Figure 2 illustrates an example layout of a documentation page that users could see in a web browser. Users could share different types of information on the pages, e.g., questions about or mistakes within the article, their experience utilizing features, or tips they found. Users could access the documentation from the firm's Website or from the help menu in the software.

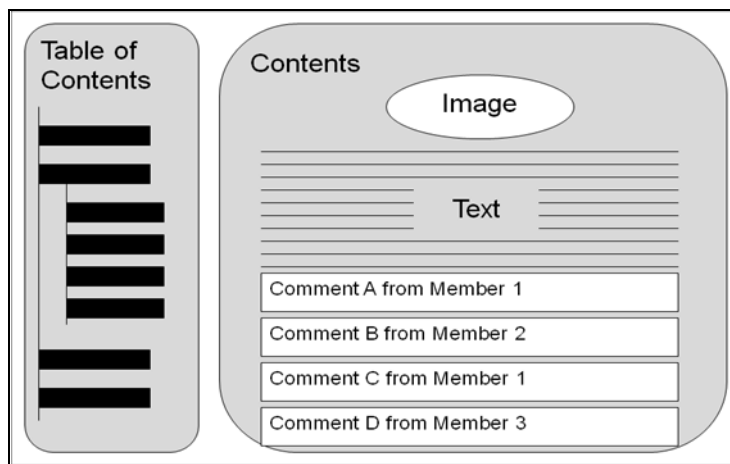


Figure 2. An example layout of an online documentation page.

In order to maintain the quality of community content and motivate members' participation, the firm adopted a moderation process. There were three roles in the community: administrator, moderator, and users. Administrators were responsible for recruiting moderators, setting policies, and playing a strategic role in managing the community. This role was filled by technical writers employed by the company. Moderators were content experts who were encouraged to contribute their expertise to the community by answering questions and sharing their experience. They were also authorized to remove unrelated posts and to assign community points to valuable comments. Users were community participants who used the software. They

were encouraged to post comments and share their expertise and experiences with the community.

The moderation process starts with a user submitting a comment to the community on a documentation page. This comment then goes to a database that only moderators and administrators can access. When a moderator reviews the comment, he evaluates whether it is related to the content and whether it is valuable to other community users. If it is not related, the comment is redirected to other appropriate places. If it is a valuable comment, the moderator assigns points based on quality.

The point system does not represent any monetary reward; it is a system of honor that implies users' levels of experience with the software. This system was designed to increase users' motivation to contribute to the community. There are five membership levels in the community through which users advance automatically after receiving a certain number of points. A user's level is identified by an icon associated with the user's ID on the personal profile page on the firm's site. The profile page is publicly available with the individual's photo, his brief bio, interests, community points, a membership icon, and other websites that he owns. When a user reaches the highest level, the firm would reward the user with a special badge. This badge could be placed on the user's own website, to indicate the user's extensive knowledge of the software.

Moderators assigned points to each comment based on the point scheme developed by the firm. This detailed point scheme (Moderating comments, 2008, October 27) is presented in Table 4. No points would be assigned to people seeking help or answers to questions, because such comments did not add additional value to the content. For those comments that identified mistakes or provided additional resources, different amounts of points were assigned.

Administrators held a two-hour training to communicate the moderation process and point scheme to moderators for the purpose of maintaining reliable and consistent moderation.

Table 4

Point Scheme for Comments

Points	Content of comments
0 Point	A relevant question or a request for clarification: Comments can be answered by a community member or a moderator.
5 Points	A typo or obvious correction: This is apparent to any user, regardless of skill.
10 Points	A minor correction or addition: This requires basic understanding of the product or technique described on a page.
20 Points	A more complex addition or tip: Comments require moderate to advanced understanding of the product.
50 Points	An advanced-level addition or tip (e.g., a detailed code example, a mini tutorial, or a multi-paragraph article).

Participants

Description of sampled population.

Common characteristics of community members were that they all used the software to practice their jobs in design. Within the community, there were sub-communities that communicated in different languages, e.g., French or Japanese. Since the English community was relatively larger and more active than the other sub-communities, this research only focused on those who participated in English communities. Participation in this community was open to all users, not just those in English-speaking countries. However, a good knowledge of English would have been required to read the documents and participate.

The research only studied users who posted at least one comment from November, 2008 to March, 2009. Administrators and moderators were excluded from the study, due to a belief that they might have different motivation to participate in the community. One thousand and one

participants in total posted at least one comment in the English community during this period. Due to the size of the population, the research invitation was sent to the whole population.

Description of participants.

Research invitations were sent to all 1001 community members. Fourteen of them were undeliverable. Three hundred and fifteen members responded to the survey. The response rate was 32 percent. After review, 286 responses were regarded as usable for data analysis. The unusable responses included those that were partially blank with only limited questions answered.

Participants' actual contributions.

The distribution of quality and quantity of actual contributions was skewed. The quality of contributions ranged from 0 to 50; the mean score was 1.06 (standard deviation = 4.22). Of the 285 respondents, only 15 percent of respondents had any points (see Table 5) and only 18 percent of them posted more than once (see Table 6). Only 4.1 percent of the respondents provided more than five contributions.

Table 5

Distribution of Quality of Contributions

Points	Frequency (Percent)
0	244 (85.3)
0.8	1 (0.3)
1.5	1 (0.3%)
1.7	2 (0.7%)
1.8	1 (0.3%)
2.0	1 (0.3%)
2.5	7 (2.4%)
2.7	2 (0.7%)
4.2	1 (0.3%)
5.0	16 (5.6%)
6.7	1 (0.3%)
7.5	1 (0.3%)
10.0	2 (0.7%)
20.0	4 (1.4%)
22.5	1 (0.3%)
50.0	1 (0.3%)
Total	286 (100.0%)

Table 6

Distribution of Quantity of Contributions

Number of contributions	Frequency (Percent)
1	206 (72.0%)
2	48 (16.8%)
3	14 (4.9%)
4	4 (1.4%)

(continued)

Table 6 (continued)

Number of contributions	Frequency (Percent)
5	6 (2.1%)
6	3 (1.0%)
7	1 (0.3%)
11	1 (0.3%)
13	1 (0.3%)
31	1 (0.3%)
33	1 (0.3%)
Total	286 (100.0%)

Participants' gender and age.

There were 208 (72.7 percent) male and 78 (27.3 percent) female respondents. The average age for the males was 43.02 and 44.24 for the females. The summary statistics are shown in Table 7. This present research had a similar respondent profile to a previous large-scale survey study done by the firm in 2008 (Abatecola, 2008). In that study, it also indicated the gender breakdown was about 70 percent male versus 30 percent female and the average age was 42.

Table 7

Respondents' Ages Across Gender

Gender	<i>M</i>	<i>SD</i>	Minimum	Maximum
Male	43.02	13.19	18	78
Female	44.56	12.64	18	66
Total	43.45	13.03	18	78

Participants' levels of expertise.

There were three questions regarding levels of expertise: Levels of experience with software, years of experience in their profession, and frequency of using the software. As seen in Table 8, all of the respondents had used the software, and only 9.8 percent of respondents were beginners. Most participants reported that they were intermediate, advanced, or expert users. More than one third of respondents (37.7 percent) had more than 9 years experience in the profession. Nearly half of them (50.9 percent) used the software daily; only 11.3 percent used the software either monthly or less than monthly. The majority of participants in this study were experienced and frequent users.

Table 8

Frequency and Means for Levels of Expertise

	Levels of expertise	n (percent)
	Levels of experience with the software (N=286)	
Beginner		28 (9.8)
Intermediate		90 (31.5)
Advanced		100 (35.0)
Expert		68 (23.8)
	Years of experience in the profession (N=284)	
Less than 1 year		46 (16.2)
More than 1 year but less than 3 years		36 (12.7)
More than 3 years but less than 5 years		33 (11.6)
More than 5 years but less than 7 years		35 (12.3)
More than 7 years but less than 9 years		27 (9.5)
More than 9 years		107 (37.7)
	Frequency of using the software (N=285)	
Less than once per month		13 (4.6)
Monthly		19 (6.7)
2 to 3 times per month		31 (10.9)
Weekly		77 (27.0)
Daily		145 (50.9)

Instrument

The questionnaire enclosed in Appendix A included three sections: levels of expertise, epistemic beliefs, and self-reported contributions to the community. They are further discussed in the following sections.

Levels of expertise.

Levels of expertise included levels of experience with the software (Never used, Beginner, Intermediate, Advanced, and Expert), years of experience in the profession (ranging from less than 1 year to more than 9 years), and frequency of using the software (Daily, Weekly, 2 to 3 times per month, Monthly, and Less than once per month). The combination of these three questions provided respondents' profiles of expertise, not only in using the software, but also in the design profession.

The categories and descriptions of expertise were adapted from the categories proposed by Dreyfus and Dreyfus (1986). According to the reviews in chapter 2, key characteristics for identifying expertise included extent of knowledge structure, ability to transfer learned skills to a new context, and problem-solving skills. The descriptions of each level were developed based on these three characteristics. *Never used* was described as, "I have never used the product."

Beginner was described as, "I know of a few features, only some of which I actually know how to use." *Beginners* could use objective facts and apply them using over-simplified rules. However, they might not be able to apply the oversimplified rules in the new context.

Intermediate was defined as, "I am familiar with enough features to get the job done but I still have a lot to learn." In contrast to *Beginners*, *intermediate* users could apply learned facts and functionality of features to a new, real-world practice. Compared with advanced users, they had limited problem-solving skills. *Advanced* was defined as, "I confidently use and understand

many of the features and can troubleshoot common problems.” *Expert* was defined as “I am highly skilled in most (or all) of the features and can troubleshoot most of the problems I encounter.” The differences between advanced users and experts were their troubleshooting abilities and their knowledge of the software.

Domain-focused epistemic beliefs.

This study adopted the *domain-focused epistemological beliefs questionnaire* (DEBQ) developed by Hofer (2000). This questionnaire was developed based on a model proposed by Hofer and Pintrich (1997) with four assumed factors: certainty of knowledge, simplicity of knowledge, source of knowledge, and justification for knowing. This questionnaire included 27 items with a 5-point Likert scale (1 = *strongly disagree*; 5 = *strongly agree*). They evaluated individual’s epistemic beliefs in two different knowledge domains, psychology and science. Certain/simple knowledge had eight items with Cronbach α equal to .74 in psychology and .81 in science; justification for knowing had four items with Cronbach α equal to .56 and .61; source of knowledge had four items with Cronbach α equal to .51 and .64; and attainability of truth had two items with Cronbach α equal to .60 and .71. For psychology, 46 percent of the variance was explained; for science, 53.14 percent of the variance was explained.

Initial adaptation.

Minor word changes were made from the DBEQ, due to the different population. For example, textbooks were changed to books; professors and scholars were changed to experts; researchers were changed to theorists; and answer was changed to design solution. In order to be more specific to the domain of design, all terms “in this field” and “in this subject” were replaced by “in the field of design” or “in design.” As a result of this modification, only two items did not have the term “design” included in the statement.

Pilot study.

The purpose of the pilot study was to check the clarity of each item in the questionnaire of domain-focused epistemic beliefs and to test whether the language was understandable for design professionals. According to Gall, Gall, and Borg (2003) and Fowler (2002), the number of participants for a pilot study was often about two to three and always fewer than ten people. The pilot study from this research included three interviewees with different design backgrounds. One was a content writer for design professionals, another was a graphic designer, and the other was a Web designer. They were all advanced users of the software and had five years or more of work experience in design. The method allowed the questionnaire to encompass different perspectives in the field of design.

The researcher interviewed three participants in person. Before the interviews, they were required to complete an online questionnaire and sign a consent letter. During the interview, the researcher first explained the purpose of the pilot study. Participants were provided an electronic feedback form, which included all items in the questionnaire. Then, they were given two options on each item, *clear* or *unclear*, and required to write reasons in a text box next to each item. They were encouraged to select *unclear* if they sensed other designers might have difficulties in understanding the questions. The researcher facilitated participants to answer reasons of why it was *unclear* by asking two questions: (a) What do you think the question is asking? (b) Is there a better term to include this concept (a concept that an interviewee described in the first question)? The entire interview process took 30 to 50 minutes. Interviewees received \$25 in compensation after the interviews.

Nine out of 27 questions were revised based on results of the pilot study. There were three common issues. First, the term, *experts*, was confusing to the participants. They were

uncertain what the term, experts, was referring to. They suggested several alternative terms, including experienced designers, professional designers, and design theorists. The term *experienced designers* was used to replace *experts* in Hofer's questionnaire because it was more specific. The term *design theorists* was used to replace professors, scholars, or researchers in Hofer's questionnaire. Second, two interviewees reported that the phrase *real-world problems* was too general; it was changed to *real-life design problems* in an updated version. Third, because the word *truth* was unclear to all interviewees, it was further revised as *truth about design problems*. The three interviewees also confirmed the clarity of these changed items through either emails or phone conversations. The final version of the questionnaire is presented in the Appendix A.

Self-reported likelihood of contributions to a community.

The variables of the self-reported contributions to a community were developed based on the point scheme (see Table 4) that was used in the community. Seven statements were used to describe various situations in which community members might post a comment. Participants were asked to rate how likely they were to submit a comment by using a 5-point Likert scale (1 = *not at all likely to submit a comment*; 5 = *extremely likely to submit a comment*). These statements described different levels of contributions to the community and different time requirements for putting effort into posting a comment. Likelihood of sharing low-level contributions represented zero points in the point scheme presented in Table 4, including asking questions or requesting clarification. Likelihood of sharing mid-level contributions represented 5 and 10 points that concerned a typo or a criticism. Likelihood of sharing high-level contributions represented 20 and 50 points that were related to sharing tips, tutorials, and other useful resources.

Quantity and quality of contributions.

Both quality and quantity of contributions were based on data gathered on the community site rather than through the survey. The researcher had access to the comment logs recorded by the site, which were matched to survey responses via the respondents' email addresses. The quantity was represented by the total number of posted comments by users, and the quality was represented by the total points that each user received.

Procedure

An invitation to participate in the research was sent to 1001 community members through the email addresses that they provided when they applied for a community account. The invitation described the purpose of the study and clarified the requirements for participants. If they decided to participate in the study, they were told to click on the link provided in the invitation and then respond to the questionnaire. The process took participants approximately 15 minutes to complete. A follow-up email was sent to potential participants one week after they received the first invitation.

Analysis

A quantitative approach was used to identify the structure of epistemic beliefs, examine the differences of epistemic beliefs across levels of expertise, and test how these variables relate to users' self-reported contributions and their actual behaviors. All analyses were conducted using SPSS 17.0. Missing values were deleted using the listwise method. The analysis began by reporting response rates and descriptive statistics for respondents' personal profiles. The descriptive statistics included frequency distributions of respondents' age, gender, levels of

experience with software, years of experience in the profession, and frequency of using the software.

In order to identify the structure of epistemic beliefs, exploratory factor analysis (EFA) was conducted. Tabachnick and Fidell (2007) described the goals of factor analysis (FA) in the following:

The specific goals of PCA or FA are to summarize patterns of correlations among observed variables, to reduce a large number of observed variables to a smaller number of factors, to provide an operational definition (a regression equation) for an underlying process by using observed variables, or to test a theory about the nature of underlying processes. (p. 608)

Through the analysis, the number and type of latent variables that fit the data were found. Items with factor loadings above .4 were selected. For the extracted factors, Cronbach alpha reliability was measured.

Next, factor scores were created by summing scores on variables that loaded highly on each factor. This method was suggested over using a regression approach to estimating factor scores, since the regression method capitalizes on chance relationships among variables, which results in biased factor-score estimates (Tabachnick & Fidell, 2007). Regarding factors of epistemic beliefs and different measures of contributions, zero-order correlations were used in order to understand the strength and direction of their linear relationships. The contributions to the community included five variables: self-reported likelihood of sharing low-level contributions, self-reported likelihood of mid-level contributions, self-reported likelihood of high-level contributions, quality of actual contributions, and quantity of actual contributions.

Finally, in order to understand the relationship among levels of expertise, epistemic beliefs, and contributions— five regression analyses were conducted. The five contribution variables were the dependent variables. The independent variables were: age, gender, three

variables for levels of expertise (i.e., levels of experience with software, years of experience in the profession, and frequency of using the software), factors of epistemic beliefs, and interaction terms between three variables for levels of expertise and factors of epistemic beliefs.

Two different methods of regression analysis, hierarchical regression and regression with backward selection, were conducted in this current research. Hierarchical regression analysis was used, in order to examine whether respondents' levels of expertise, the factors of epistemic beliefs, and the interaction between the two components made a significant and unique contribution to the prediction of three different levels of self-reported contributions. Since the distribution of actual contributions was skewed, those who did not receive any points and posted only once between November, 2008 and March, 2009 were removed from the regression analyses. After removing these respondents, the distribution was closer to a normal distribution. Additionally, since the new data sets of quality (N=39) and quantity (N=73) of actual contributions were small, two regression analyses with backward selection were conducted, instead of hierarchical regression analyses, in order to decrease the degree of freedom.

Chapter 4

Results

This chapter presents an overview of the results of the study, a discussion of the sample, and the detailed results of statistical analyses that addressed the following research questions:

1. What is the structure of domain-focused epistemic beliefs relative to the structure, stability, source, and justification of knowledge in the field of design?
2. How do demographic characteristics – age, gender, expertise – relate to individual levels of contribution to an online community of practice hosted by a firm?
3. How do individuals' design-focused epistemic beliefs relate to their levels of contribution to an online community of practice hosted by a firm?
4. How does the interaction between expertise and design-focused epistemic beliefs relate to individual levels of contribution to an online community of practice hosted by a firm?

Results are organized first by method use, then by research question. First, results of exploratory factor analysis are shown for the purpose of discovering the structure of epistemic beliefs. Next, findings from correlation and five regression analyses are presented. Finally, the presentation of the results is organized by the research questions.

Structure of Epistemic Beliefs

The following section details the results of structural analyses of each of the scales used in the current study, including results of principal axis factor analysis and internal consistency reliability analysis. The findings then lead to a discussion of the differences between the factors identified in this current study and the factors found in the Hofer (2000) and Wood and Kardash (2002) studies.

Exploratory factor analysis.

Appendix B presents the means and standard deviations for each of the items used to define the epistemic beliefs factors. In this research, missing values were deleted using a listwise method. Most values of the inter-item correlation were in the low to moderate range. The data were analyzed using principal axis factor analysis (PAF). The Kaiser criterion and scree plot were used to estimate the number of factors to extract. There were 10 eigenvalues greater than 1 that accounted for 61.4 percent of the total variance.

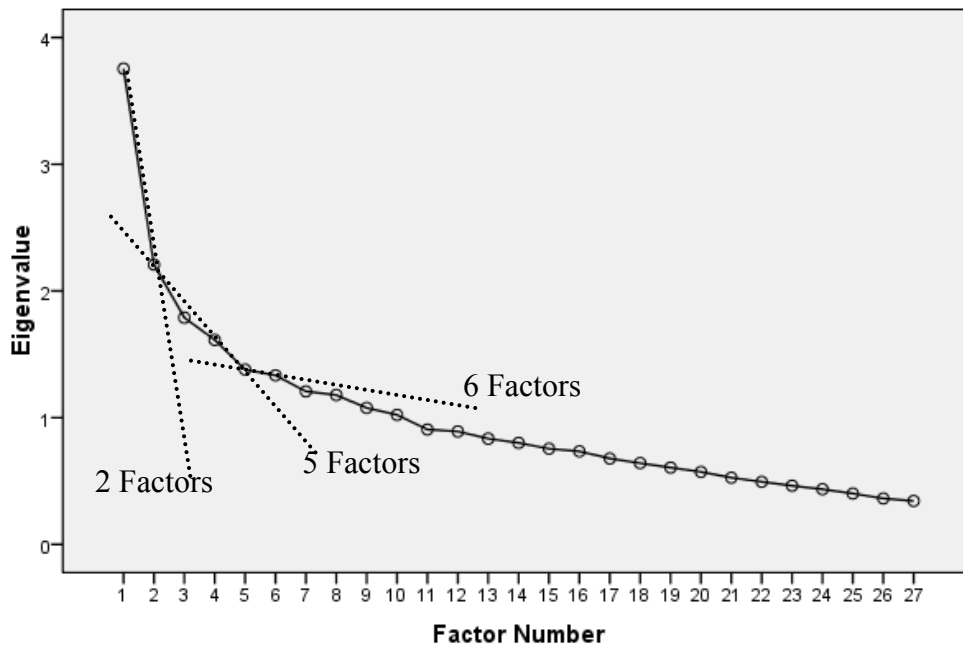


Figure 3. Scree plot of factors.

In social science data analysis, it is not unusual to extract several factors; however, the more factors extracted, the less parsimonious the solution (Tabachnick & Fidell, 2007). Rather than using eigenvalue over one, a scree test of eigenvalues plotted against factors is another method often used to determine the number of factors. The point at which a line drawn through the points changes slope is the number of factors that is suggested for extraction. As shown in Figure 3, the scree plot appeared to support two to five factors. Since a four-factor solution was

suggested by the theoretical structure of the scale, four factors were extracted and they accounted for 34.7 percent of the total variance. Principal factors extraction with direct oblimin rotation was performed on 27 items for the sample of 286 respondents. Oblique rotation allows for the existence of correlations between factors. Four factors with high loadings ($>.4$) were identified, and high cross-loadings ($>.3$) are reported in Table 9. Thirteen of 27 items did not load on any factor. These items included questions regarding beliefs about first-hand experience, justification of design principles, and individual construction of meaning. Using these methods, the four factors extracted were labeled (a) Consistency of Design Knowledge, (b) Source Authority of Design Knowledge, (c) Attainability of Design Knowledge, and (d) Contextual Factuality of Design Knowledge.

Table 9

Factor Loadings for Exploratory Factor Analysis With Direct Oblimin Rotation of Epistemic Beliefs

Item	Pattern				Structure			
	Consistency of Design Knowledge	Source Authority of Design Knowledge	Attainability of Design Knowledge	Contextual Factuality of Design Knowledge	Consistency of Design Knowledge	Source Authority of Design Knowledge	Attainability of Design Knowledge	Contextual Factuality of Design Knowledge
1: Theories are unchanging in the field of design.	-.52				-.52			
5: All design theorists would probably come up with the same solutions to problems.	-.56				-.61			(.37)
9: Most of what is true in the field of design is already known.	-.50				-.54	(.30)		
18: Principles in the field of design are unchanging.	-.55				-.53			
24: All experts in design understand the field in the same way.	-.49				-.55	(.33)		
7: If you read something in a book for design, you can be sure it is true.		.53				.55		
8: A theory in design is accepted as correct if experts reach consensus.		.45				.48		
20: If my personal experience conflicts with ideas in a book, the book is probably right.		.68				.66		
26: I am most confident that I know something when I know what the experts think.		.44				.44		
22: Expertise in the field of design consists of seeing the interrelationships among ideas.			.44				.43	
23: Solutions to problems in design change as experts gather more information.			.49				.49	

(continued)

Table 9 (continued)

Item	Pattern				Structure			
	Consistency of Design Knowledge	Source Authority of Design Knowledge	Attainability of Design Knowledge	Contextual Factuality of Design Knowledge	Consistency of Design Knowledge	Source Authority of Design Knowledge	Attainability of Design Knowledge	Contextual Factuality of Design Knowledge
27: First-hand experience is the best way of knowing something in design.			.41				.41	
12: Correct solutions in the field of design are more a matter of opinion than fact.				.51				.49
21: There is really no way to determine whether someone has the right solution in design.				.53				.53

Descriptive statistics for factors of epistemic beliefs.

There were 5 items in Consistency of Design Knowledge, 4 items in Source Authority of Design Knowledge, 3 items in Attainability of Design Knowledge, and 2 items in Contextual Factuality of Design Knowledge. Factor scores were calculated by adding item scores together. Consistency and Source Authority of Design Knowledge had a medium correlation ($r=.34$, $p<.01$). Attainability and Contextual Factuality of Design Knowledge were both not significantly correlated with any other factors of epistemic beliefs. The Cronbach α ranged from .47 to .69. Consistency and Source Authority of Design Knowledge had higher internal consistency than Attainability and Contextual Factuality of Design Knowledge. These findings and the implications are discussed at length in Chapter 5. Table 10 presents the descriptive statistics and Cronbach α .

Table 10

Descriptive Statistics and Reliability of Factors of Epistemic Beliefs

Factor	1	2	3	4
1. Consistency of Design Knowledge	1			
2. Source Authority of Design Knowledge	.34**	1		
3. Attainability of Design Knowledge	-.04	-.08	1	
4. Contextual Factuality of Design Knowledge	-.01	.01	-.03	1
Number of items	5	4	3	2
<i>M</i>	10.54	10.15	11.83	6.14
<i>SD</i>	3.14	2.35	1.54	1.64
Cronbach α	.69	.61	.47	.52

Note: ** $p < .01$.

Comparison to previous studies using similar factors.

The four factors of epistemic beliefs that emerged were somewhat different from Hofer's (2000) findings. Consistency of design knowledge included items that were related to both certainty and simplicity of knowledge. Similar to Hofer's findings, the current study found that beliefs about certainty and simplicity of knowledge were not two separate factors. They were instead one combined factor in which knowledge is viewed as fixed, unchanging, unambiguous, and consistent across design experts. All of the items in the Consistency of Design Knowledge factor from this study also loaded on certain/simple knowledge in Hofer's study (see Table 11).

The second factor, Source Authority of Design Knowledge, reflects that knowledge comes from an authority, such as books or an expert. If an individual's knowledge conflicts with that of an authority, the individual is more likely to accept the ideas conveyed by the authority. All items in this factor were also loaded on the source of knowledge: authority in Hofer's study, except item 8 which was not loaded on any factors in Hofer's study. However, this item is clearly related to how people think of the knowledge distributed from an authority.

In terms of the third factor, similar to findings in both Hofer's study and in Wood and Kardash (2002), the three items of Attainability of Design Knowledge emerged as one single factor. This factor represents both how individuals and experts acquire design knowledge and the degree of difficulty experienced in attaining that knowledge. High scores represent the view that design knowledge needs more effort to be acquired and that objectivity does not exist. However, the factor, Attainability of Design Knowledge, is to some extent different from the original factor of the two previous studies. As shown in Table 11, items in this research were different from those items loaded on attainability of truth in Hofer's study. The difference might also contribute to the low internal consistency in this factor. Hofer's and Wood and Kardash's factors focused

on the attainment of objective truth. The factor in the present study was concerned with beliefs about design knowledge, which had a broader perspective.

The fourth factor, Contextual Factuality of Design Knowledge, reflects how individuals assess knowledge and decide which solutions are correct. While the Contextual Factuality in the current study was very close to justification for knowing: personal in Hofer's study, this study did not include the belief about first-hand experience, which was covered by items 25 and 27. Since the last two factors, Attainability of Design Knowledge and Contextual Factuality of Design Knowledge, had very low internal consistencies and were not reliable, the factors were not entered in the regression analyses. This provided a cleaner and more reliable result for the regression analyses.

Table 11

Comparison of Factors in This Study and in Hofer's Study

Factor	Items in this current research	Items in Hofer's (2000) study	Compare this study with Hofer (2000)
Consistency of Design Knowledge	1, 5, 9, 18, 24	1, 2, 5, 9, 11, 18, 23, 24	All items from this research were loaded on certain/simple knowledge in Hofer's study.
Source Authority of Design Knowledge	7, 8, 20, 26	3, 7, 20, 26	<ul style="list-style-type: none"> Item 8 was not loaded on any of Hofer's factors. Other 3 items were all loaded on source of knowledge: authority in Hofer's study.
Attainability of Design Knowledge	22, 23, 27	13, 17	Factor in this study focused on the attainment of "Design Knowledge" vs. attainment of "Facts" in Hofer's factor.
Contextual Factuality of Design Knowledge	12, 21	12, 21, 25, 27	Items from this research were loaded on justification for knowing: personal in Hofer's study. However, the factor in this study focused only on the contextual characteristic of design knowledge but not first-hand experience.

Modeling the Relations Between Age, Gender, Level of Expertise, Epistemic Beliefs, and Contributions

The following section first presents the descriptive statistics for all variables, including means, standard deviations, and correlations between variables. Next, findings from the regression analyses are shown, including three hierarchical regression analyses for self-reported likelihood of contributions and two hierarchical regression analyses with backward selection for participants' quality and quantity of actual contributions. The findings from these regression analyses are then further explored in relation to the above-referenced research questions, including the relations between demographic characteristics and individual level of contributions, the relations between individuals' design-focused epistemic beliefs and contributions, and the interaction between expertise and design-focused epistemic beliefs in relation to contributions. Due to the low internal consistency of Attainability of Design Knowledge and Contextual Factuality of Design Knowledge, these two factors of epistemic beliefs were not included in the following analyses.

Descriptive statistics for age, gender, level of expertise, epistemic beliefs, and contributions.

Scores of self-reported likelihood of contributions were averaged by their corresponding items (Item 1 and 2 in section III in Appendix A). Low-level contributions were the postings provided when individuals had questions about using the software or needed clarification about a help page. Mid-level contributions were the postings provided when individuals found typos or disagreed with the information published on a help page. High-level contributions were the postings provided when individuals found relevant tips or information from other sources, had ideas of how to enhance content, or wanted to share relevant instructions they had created.

In terms of average scores of self-reported likelihood of sharing contributions, people rated the low-level and high-level contributions higher than the mid-level ones (see Table 12). More specifically, the average likelihood of sharing was lowest when people found a typo or disagreed with information on a help page. In addition, the average scores for quality and quantity of actual contributions were both around one. This was due to the skewed distribution of quality and quantity of contribution. Most people posted only once (73.4 percent) and received zero points (86.1 percent).

In terms of correlations between the demographic variables, there was no significant correlation between age and gender. Correlations showed that the three variables for levels of expertise had medium correlations with each other, ranging from .33 to .57. For the epistemic beliefs, as expected, higher scores of Consistency of Design Knowledge were associated with higher scores of Source Authority of Design Knowledge ($r = .34, p < .01$) (see Table 10). For the five contribution variables, quality of actual contributions was positively and significantly associated with the likelihood of sharing high-level contributions ($r = .17, p < .01$); quantity of actual contributions was associated with the likelihood of sharing mid-level contributions ($r = .19, p < .01$). However, quality and quantity of actual contributions were not significantly correlated with the likelihood of sharing low-level contributions.

In this paragraph, the correlations between all of the independent variables and the five contribution variables are presented. In terms of the demographic variables, age did not correlate with any of the contribution variables. However, for gender, correlations revealed that females reported a higher likelihood of sharing low-level contributions ($r = .14, p < .05$), and males reported a higher likelihood of sharing mid-level contributions ($r = -.14, p < .05$). Although the three variables for levels of expertise had medium correlations with each other, they related

differently to the contributions. Levels of experience using software was significantly and positively correlated with quality of contributions ($r = .15, p < .05$). More years of experience in the design profession was associated with a lower likelihood of sharing low-level contributions ($r = -.14, p < .05$) and higher quality of contributions ($r = .12, p < .05$). Higher frequency of using the software was significantly and positively correlated with the likelihood of sharing both mid-level contributions ($r = .22, p < .01$) and high-level contributions ($r = .14, p < .05$). In terms of epistemic beliefs, Consistency was negatively correlated with quantity of contributions ($r = -.14, p < .05$); Source Authority of Design Knowledge did not correlate with any contribution variable.

For the correlations between levels of expertise and epistemic beliefs, levels of experience with the software was negatively associated with Source Authority of Design Knowledge ($r = -.18, p < .01$). As expected, more experience in the design profession was associated with lower scores of Consistency ($r = -.13, p < .05$) and lower scores of Source Authority ($r = -.26, p < .01$). Noticeably, frequency of using the software did not correlate with any of the epistemic belief variables.

Table 12

Correlations Between Contributions and Factors of Epistemic Beliefs

Variable	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
1. Age	1											
2. Gender	.04	1										
3. Levels of Experience with Software	-.14*	-.13*	1									
4. Years of Experience in the Profession	.13*	-.01	.57**	1								
5. Frequency of Using the Software	.03	-.05	.47**	.33**	1							
6. Consistency of Design Knowledge	-.22**	-.05	-.01	-.13*	.02	1						
7. Source Authority of Design Knowledge	-.21**	-.05	-.18**	-.26**	-.06	.35**	1					
8. Likelihood of Sharing Low-level Contributions	.04	.14*	-.10	-.14*	.08	.01	.04	1				
9. Likelihood of Sharing Mid-level Contributions	-.01	-.14*	.09	.06	.22**	-.11	.01	.29**	1			
10. Likelihood of Sharing High-level Contributions	.05	-.11	.03	.03	.14*	-.07	.00	.41**	.43**	1		
11. Quality of Contributions	.01	-.05	.15*	.12*	.07	-.01	-.02	-.03	.06	.17**	1	
12. Quantity of Contributions	.07	-.07	.05	.03	.10	-.14*	-.02	-.10	.19**	.07	.047	1
<i>M</i>	43.23	-	3.73	3.97	4.13	10.50	10.17	3.50	2.76	3.06	1.05	1.67
<i>SD</i>	13.12	-	.94	1.92	1.12	3.19	2.38	.83	.87	.86	4.32	2.26

Note: Gender is coded male = 1, female = 2

* $p < .05$. ** $p < .01$.

Regression analysis for self-reported likelihood of contributions and actual contributions.

Three separate hierarchical regression analyses for self-reported likelihood of contributions and two regression analyses for actual contributions with backward selection were conducted. Different methods were used due to the skewed distribution of quality and quantity of actual contributions. More discussion about this issue is presented in Chapter 3.

Self-reported likelihood of contributions. Three hierarchical regression analyses were used to examine whether each of the following four sets of variables made a significant and unique contribution to the prediction of self-reported likelihood of providing contributions. For each analysis, two demographic variables, gender and age, were first entered into the equation as a block. Next, the three variables for levels of expertise were entered as a block (levels of experience with software, years of experience in the profession, and frequency of using the software) to determine whether they accounted for a statistically significant increase in the amount of variance after the control variables had first been entered. In the third step, after controlling for gender, age, and levels of expertise, two factor scores of epistemic beliefs were entered to investigate whether the variables made a statistically significant contribution to explain self-reported likelihood of contributions. The last block comprised six first-order interaction terms between levels of expertise and epistemic beliefs. Missing values were removed using listwise deletion. Eleven outliers for low-level contributions, seven outliers for mid-level contributions, and nine outliers for high-level contributions were also removed. This resulted in a total size of 264 respondents for all three self-reported likelihood of contributions. Table 13 presents the summary of hierarchical regression analyses for the variables that predict self-reported likelihood of contributions.

Table 13

Summary of Hierarchical Regression Analyses for Variables Predicting Self-reported Likelihood of Contributions (N = 264)

Independent Variables	Dependent Variables: Contributions		
	Self-reported likelihood of sharing low-level contributions	Self-reported likelihood of sharing mid-level contributions	Self-reported likelihood of sharing high-level contributions
Step 1 - Demographic Information			
ΔR^2	0.039**	.022 [†]	.025*
Gender	.198**	-.146*	-.149*
Age	-.021	-.011	.056
Step 2 – Levels of expertise			
ΔR^2	0.069***	.059**	.039*
Gender	.193**	-.146*	-.154*
Age	-.003	-.024	.039
Levels of experience with the software (LE)	-.052	-.075	-.084
Years of experience in the profession (YE)	-.223**	-.028	-.009
Frequency of using the software (Fq)	.194**	.272***	.222**
Step 3 – Epistemic Beliefs			
ΔR^2	0.008	.030*	.022*
Gender	.201**	-.147*	-.159**
Age	.014	-.041	.021
Levels of experience with the software (LE)	-.040	-.064	-.074
Years of experience in the profession (YE)	-.209**	-.038	-.017
Frequency of using the software (Fq)	.189**	.276***	.227**
Consistency of Design Knowledge (C)	.009	-.183**	-.157*
Source Authority of Design Knowledge (SA)	.089	.098	.071
Step 4 – Interaction between Epistemic Beliefs and Levels of expertise			
ΔR^2	0.044*	.033	.034
Gender	.208**	-.145*	-.151*
Age	-.001	-.042	.021
Levels of experience with the software (LE)	-.773*	-.627 [†]	.705 [†]
Years of experience in the profession (YE)	.243	.054	-.778*
Frequency of using the software (Fq)	.607 [†]	.184	-.303
Consistency of Design Knowledge (C)	.005	-.533 [†]	-.078
Source Authority of Design Knowledge (SA)	-.050	-.194	-.071
C * LE	1.263**	1.049*	-.090
C * YE	-.406	-.237	.283
C * Fq	-1.051**	-.461	-.205
SA * LE	-.066	-.118	-.855*
SA * YE	-.097	.124	.526
SA * Fq	.365	.512	.807*
Total R^2	.160	.143	.120
N	264	264	264

Note. Standardized regression coefficients are shown; gender is coded male = 1, female = 2.

[†] $p < .10$. * $p < .05$. ** $p < .01$. *** $p < .001$

With respect to the likelihood of sharing low-level contributions, demographic variables accounted for a significant part of the variance, F change (2, 261) = 5.302, $p < .01$. The three variables regarding levels of expertise accounted for 6.9 percent of the variability in the likelihood of sharing low-level contributions ($p < .001$). The subsequent entry of the two factors of epistemic beliefs did not result in a statistically significant increase in the explanation of the contributions, F change (2, 256) = .008, $p > .05$. Finally, interaction terms accounted for a significant part of the variance, F change (6, 250) = 2.180, $p < .05$. The overall model explained the likelihood of providing low-level contributions, F (13, 250) = 3.654, $p < .001$, $R^2 = .160$.

For the likelihood of sharing mid-level contributions, demographic variables did not account for a significant part of the variance. As with the likelihood of sharing low-level contributions, the three variables for levels of expertise accounted for 5.9 percent of the variability ($p < .001$). As predicted, the subsequent entry of the two factors of epistemic beliefs resulted in a statistically significant increase in the explanation of the contributions ($p < .05$), explaining an additional 3 percent of the variability, F change (2, 256) = 4.344, $p < .05$. Interaction terms did not account for a significant part of the variance, F change (6, 250) = 1.589, $p > .05$. The overall model explained the self-reported likelihood of sharing mid-level contributions, F (13, 250) = 3.222, $p < .001$, $R^2 = .143$.

In terms of the likelihood of sharing high-level contributions, demographic variables, levels of expertise, and the factors of epistemic beliefs all accounted for a significant part of the variance. Demographic variables accounted for a significant part of the variance, F change (2, 261) = 3.287, $p < .05$. Levels of expertise accounted for 3.9 percent of the variability in the likelihood of sharing low-level contributions, F change (3, 258) = 3.575, $p < .05$. The subsequent entry of the two factors of epistemic beliefs resulted in a statistically significant increase in the

explanation of the contributions, explaining an additional 2.2 percent of the variability, F change (2, 256) = 3.050, $p < .05$. Interaction terms between levels of expertise and epistemic beliefs did not account for a significant part of the variance, F change (6, 250) = 1.622, $p > .05$, after controlling for demographic variables, levels of expertise, and factors of epistemic beliefs. The overall model explained the likelihood of sharing high-level contributions, F (7, 250) = 2.611, $p < .01$, $R^2 = .120$.

Actual contributions. In terms of the actual contributions, two regression analyses with backward selection were conducted. Three variables regarding levels of expertise, two factors of epistemic beliefs, age, and gender were tested first. If any of the expertise variables were significant, the interaction terms were then entered in the regression analyses and tested again. For the quality of actual contributions, the overall model was significant and explained 27.7 percent of the variance, F (3, 34)=4.349, $p < .05$. As can be seen in Table 14, three variables significantly explained respondents' quality of contributions at an alpha level of .05, including levels of experience with software, Consistency of Design Knowledge, and interaction between these two variables.

Table 14

Regression Analysis for Variables Predicting Quality of Actual Contributions (N = 38)

Independent Variables	<i>B</i>	<i>SE B</i>	β
Constant	54.926	25.780	
Levels of experience with software (LE)	-13.276	6.178	-1.249*
Consistency of Design Knowledge (C)	-6.071	2.468	-1.993*
LE * C	1.671	.603	2.474**

* $p < .05$. ** $p < .01$.

The results for quantity of actual contributions are presented in Table 15. The overall model was significant and explained 29.4 percent of the variance, F (4, 68)=7.068, $p < .001$. Five

variables significantly explained respondents' quantity of actual contributions at an alpha level of .05, including levels of experience with software, years of experience in the profession, and three interaction terms between Consistency of Design Knowledge and expertise variables. Detailed discussion about each individual variable is presented in the following section.

Table 15

Regression Analysis for Variables Predicting Quantity of Actual Contributions (N = 73)

Independent Variables	<i>B</i>	<i>SE B</i>	β
Constant	2.830	.805	
Levels of experience with the software (LE)	2.231	.489	1.124***
Years of experience in the profession (YE)	-1.820	.412	-2.102***
C* LE	-.171	.042	-1.544***
C * YE	.140	.039	1.889***

*** $p < .001$

Age, gender, and contributions.

Age and gender were both tested with five regression analyses. Age was not significant across all types of contributions. However, gender was significant in the self-reported likelihood of sharing different levels of contributions, although not in the actual contributions (see Table 13, Step 1). With respect to the likelihood of sharing low-level contributions, males reported that they would be less likely to ask questions, and females reported that they would be more likely to ask questions and for clarification ($\beta = .198, p < .01$). For both mid-level ($\beta = -.146, p < .05$) and high-level contributions ($\beta = -.149, p < .05$), male participants were more likely than female participants to report that they would post comments. This indicated that male participants believed that they were more likely to post a comment when they found a typo, disagreed with information published on a help page, found relevant tips from other sources, or wanted to share relevant instructions that they had created.

Levels of expertise and contributions.

Levels of expertise included three variables: (a) levels of experience with software, (b) years of experience in the profession, and (c) frequency of using the software. First, levels of experience with the software was not significant for all three levels of self-reported likelihood of sharing contributions (see Table 13, Step 2), but the variable was significant for both quality (see Table 14) and quantity of actual contributions (see Table 15). There was an interaction between levels of experience with the software and belief about Consistency of Design Knowledge on quality and quantity of actual contributions. More findings are reported in the later section about interaction between levels of expertise and epistemic beliefs in relation to contributions.

Years of experience in the profession was significant for the self-reported likelihood of sharing low-level contributions and quantity of actual contributions. The longer the individuals had worked in the profession ($\beta = -.223, p < .01$), the less likely they were to ask a question online (see Table 13, Step 2). There was also an interaction with belief about Consistency of Design Knowledge for quantity of contributions. More findings can be found in the later section about interaction between levels of expertise and epistemic beliefs in relation to contributions.

The frequency of using the software was positively associated with the likelihood of sharing low-level ($\beta = .194, p < .01$), mid-level ($\beta = .272, p < .001$), and high-level contributions ($\beta = .222, p < .01$), but not the quality and quantity of actual contributions. The more frequently participants used the software, the more likely they were to post a comment when they had a question, needed clarification, found a typo, disagreed with information published on a help page, found relevant tips from other sources, or wanted to share relevant instructions that they had created (see Table 13, Step 2).

Epistemic beliefs and contributions.

With regard to epistemic beliefs, Consistency of Design Knowledge was the only significant explanatory variable for all types of contributions. As expected, the factor was negatively associated with likelihood of sharing mid-level contributions ($\beta = -.183, p < .01$), likelihood of sharing high-level contributions ($\beta = -.157, p < .05$) (see Table 13, Step 3), and quality of actual contributions ($\beta = -1.993, p < .05$) (see Table 14). The less individuals believed in consistency of design knowledge, the more likely they were to post a comment when they found a typo, disagreed with information published on a help page, found relevant tips from other sources, or wanted to share relevant instructions they had created. The belief also had an interaction with levels of the expertise in relation to quality and quantity of contributions. The detailed findings are reported in the next section.

Interaction between levels of expertise and epistemic beliefs and contributions.

Interaction for likelihood of sharing low-level contributions. For the effects of interaction between expertise and epistemic beliefs, after controlling for individuals' age, gender, levels of expertise, and epistemic beliefs, the last step was only significant for the likelihood of sharing low-level contributions. The interaction between Consistency of Design Knowledge and levels of experience with the software was positively associated with the likelihood of sharing low-level contributions ($\beta = 1.263, p < .01$) (see Table 13, Step 4); however, the interaction between Consistency of Design Knowledge and frequency of using the software was negatively associated with the likelihood of sharing low-level contributions ($\beta = -1.051, p < .01$) (see Table 13, Step 4).

In order to further understand the relation between the belief in consistency of design knowledge, levels of experience with software, and years of experience in design, four regression

lines of different levels of experience with the software were drawn (Figure 4). For each level of experience, participants' likelihood of sharing low-level contributions was examined at the mean for Consistency of Design Knowledge (10.52), at one standard deviation above the mean (13.65) and at one standard deviation below the mean (7.39). Each small graph in the Figure represents different frequencies of using the software, including daily, weekly, 2 to 3 times per month, and monthly.

As indicated in Figure 4, in general, individuals at the average level of belief in consistency of design knowledge had a similar likelihood of sharing low-level contributions, regardless of their levels of experience. However, the more frequently they used the software, the less likely they were to provide the low-level contributions. In terms of different levels of belief in consistent knowledge, the more experience those with a strong belief (above the mean) in consistent knowledge had with the software, the more likely they were to post comments when they had a question about using the software or needed clarification on a help page. On the contrary, the less experience those with a weak belief (below the mean) in consistent knowledge had with the software, the more likely they were to post comments when they had a question.

Comparing the four graphs with different frequencies of using software, advanced users and experts with a stronger belief in consistent knowledge had a higher likelihood of sharing low-level contributions than those with a weaker belief, regardless of their frequency of using the software. For beginner and intermediate users who used the software at least weekly, the more they believed in consistency of design knowledge, the less likely they were to share the low-level contributions; however, when they did not use the software as often, a weaker belief in consistency of design knowledge was related to a slightly higher likelihood of sharing the low-level contributions.

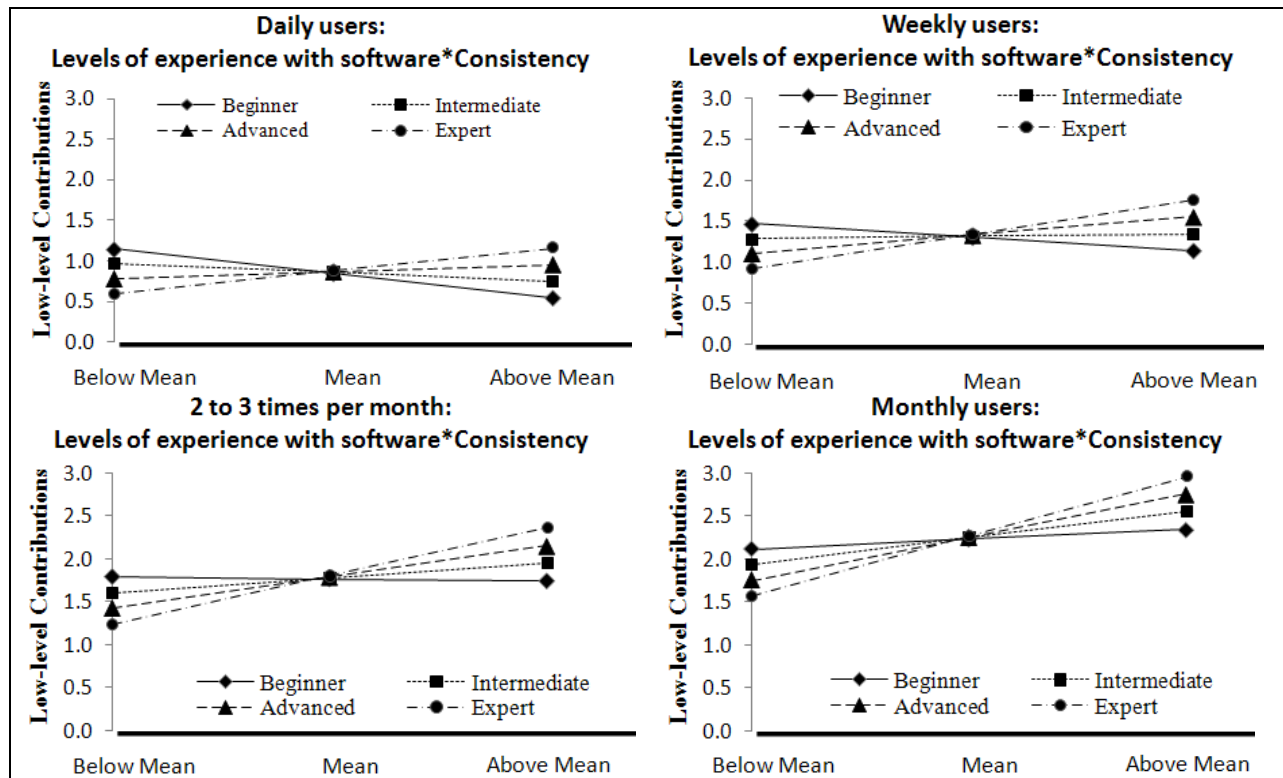


Figure 4. Interaction between frequencies of using software, levels of experience with software, and consistency of knowledge for low-level contributions.

Interaction for quality of actual contributions. The regression analysis revealed significant interactions between Consistency of Design Knowledge and level of experience with software ($\beta = 2.474, p < .05$) on quality of contributions. A similar graph was drawn in order to understand how the relationship between different levels of experience with the software and quality of contributions would depend on an individual's belief in consistent knowledge. Four regression lines of different levels of experience with the software were drawn. For each level of experience, participants' likelihood of sharing low-level contributions was examined at the mean for Consistency of Design Knowledge (10.52), at one standard deviation above the mean (13.65), and at one standard deviation below the mean (7.39). In general, when experts believed in consistent knowledge at an average or above the average level, they had higher quality contributions than less experienced users. Interestingly, when experts had a weak belief (below

the mean) in consistent knowledge, the quality of their contributions was similar to that of users with less experience. In addition, experts and advanced users contributed higher quality comments when they had a stronger believe in consistent knowledge. This unexpected result is further discussed in Chapter 5.

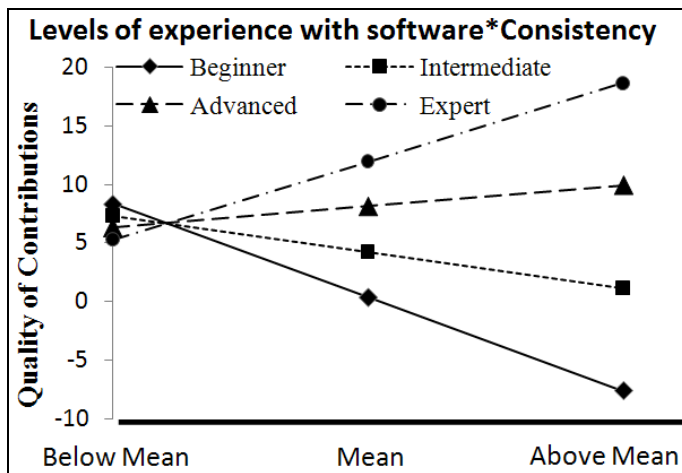


Figure 5. Interaction between levels of experience with the software and consistency of knowledge for quality of contributions.

Interaction for quantity of actual contribution. The regression analysis revealed significant interactions between Consistency of Design Knowledge and level of experience with software ($\beta = -1.544, p < .001$), and between Consistency of Design Knowledge and years of experience in design ($\beta = 1.889, p < .001$) on quantity of contributions. Using the same method to understand the relation between belief in consistent knowledge and the two variables regarding levels of expertise, four regression lines of different levels of experience with the software were drawn. For each level of experience, participants' quantity of contributions was examined at the mean for Consistency of Design Knowledge (10.37), at one standard deviation above the mean (13.46), and at one standard deviation below the mean (7.28) (see Figure 6).

From the interaction plot in Figure 6, it can be seen that the relation between levels of experience and quantity of individuals' contributions differed based on an individual's belief about Consistency of Design Knowledge. In general, those with consistent knowledge scores

above the mean provided approximately the same number of contributions, regardless of their levels of experience with the software. In contrast, those with consistent knowledge scores at or below the mean and with more software experience provided more contributions.

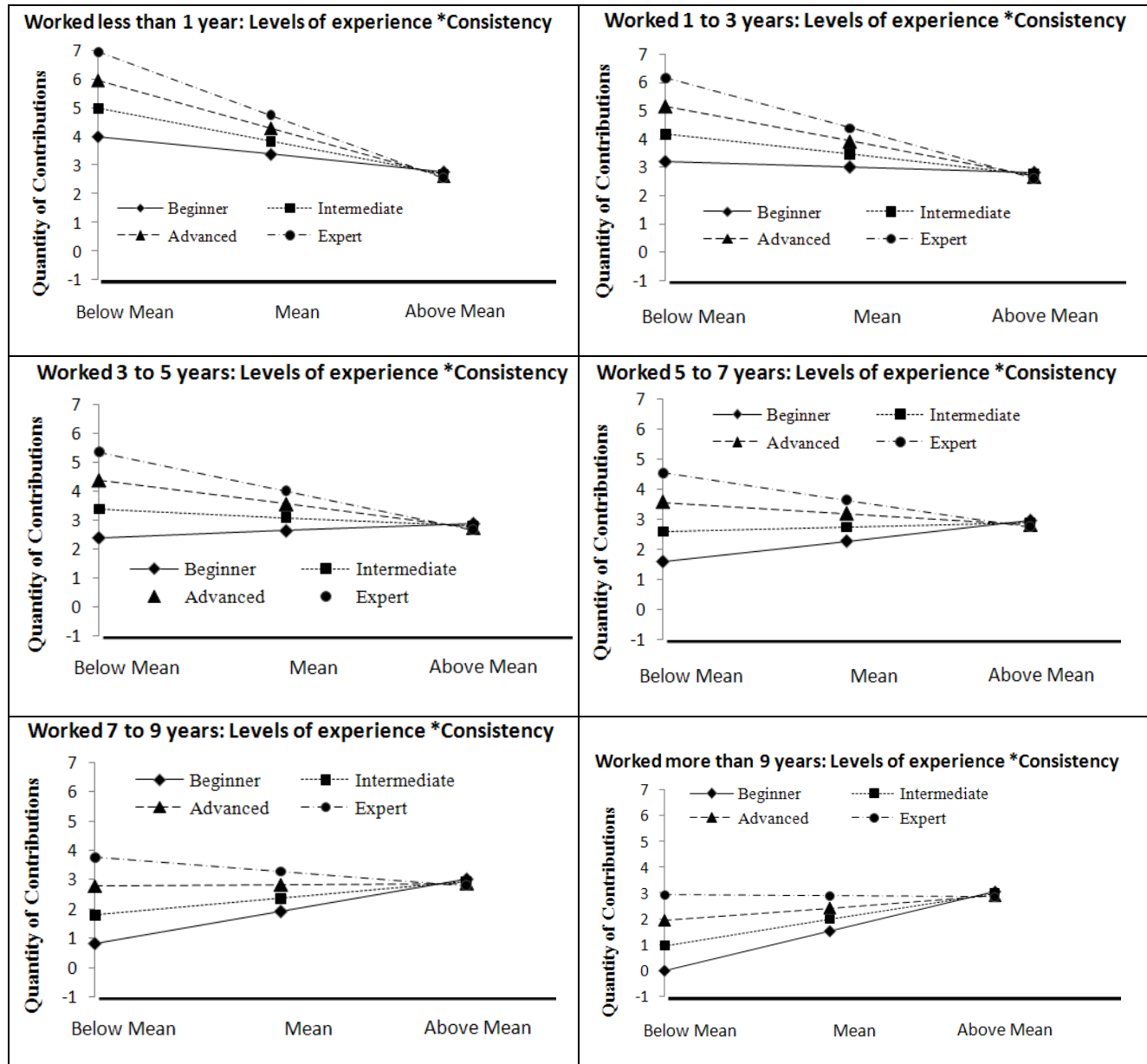


Figure 6. Interaction between years of experience in design, levels of experience with software, and consistency of knowledge for quantity of contributions.

Regardless of the number of years of experience in the design profession, expert and advanced users with consistent knowledge scores at or below the mean contributed more than

those with a strong belief in consistency of design knowledge. When they were new to the design field, beginner and intermediate users had the same results as expert and advanced users. The less they believed in consistent knowledge, the more contributions they provided. However, for beginner and intermediate users with more experience in the design field, those with consistent knowledge scores at or below the average level contributed fewer comments than those with a strong belief. An in-depth discussion of the implications of these findings is presented in Chapter 5.

In summary, the tested model explained actual contributions well, including 27.7 percent of the variance for quality of contributions and 29.4 percent of the variance for quantity of contributions. With respect to the self-reported likelihood of contributions, the tested model explained the low-level contributions ($R^2=.160$) best, followed by mid-level contributions ($R^2=.143$). The model only accounted for 12 percent of the variance in the high-level contributions.

Age was not a significant explanatory variable for the self-reported likelihood of contributions, quality, and quantity of contributions. Gender was significantly associated with all types of self-reported likelihood of contributions. Females were more likely to report that they would post a comment when they had a question or needed some clarification. In contrast, males were more likely to report that they would post a comment when they found typos and wanted to share instructions.

Considering levels of expertise, levels of experience with the software were not significant for three levels of self-reported likelihood of contributions, but the variable was significant for both quality and quantity of actual contributions. In contrast, frequency of using the software was positively associated with the low-level, mid-level, and high-level contributions,

but not the quality and quantity of contributions. The more frequently individuals used the software, the more likely they are to report a higher likelihood of providing contributions. In addition, the longer the individuals had worked in the profession, the less likely they were to share low-level contributions.

In terms of epistemic beliefs, Consistency of Design Knowledge was the only significant explanatory variable for all types of contributions. This factor was negatively associated with the likelihood of sharing mid-level and high-level contributions and quality of actual contributions. As expected, the less individuals believed in consistency of design knowledge, the more likely they were to share low-level and high-level contributions.

With respect to interaction between epistemic beliefs and levels of expertise, the interaction with level of experience with software was positively associated with the likelihood of sharing low-level contributions and quality of contributions, and negatively associated with quantity of contributions. The interaction with years of experience was positively associated with quantity of contributions. The interaction with frequency of using the software was only significant for explaining quantity of contributions. An in-depth discussion of the implications of these findings and how the present results compare to past research findings is presented in Chapter 5.

Chapter 5

Discussion

This study explored the relationship between individuals' levels of expertise, their epistemic beliefs, and their contributions to an online community of practice. As the literature in Chapter 2 revealed, several previous studies have researched the relationship between epistemic beliefs and online behaviors for high school students (e.g., Mason & Boldrin, 2008) and college students (e.g., Jacobson & Spiro, 1995). They found that epistemic beliefs influence individuals' problem-solving performance (Oh & Jonassen, 2007) and information-seeking behaviors (Hofer, 2004; Schommer, 1998; Whitmire, 2003), and that they may also influence how individuals communicate within online learning environments (Bråten, Strømsø, & Samuelstuen, 2005); Bråten & Strømsø, 2006). This present research has extended the traditional research on epistemic beliefs by demonstrating how individuals' beliefs in ways of knowing design knowledge can operate as frameworks in an online community of practice beyond school settings.

This chapter details the conclusions of the study and implications for theories, future research, and the design of an online community of practice.

Conclusions

The results of this study confirmed some findings from past research and uncovered some surprising and interesting issues, which are further discussed in this section. There are six primary conclusions that add to the limited body of research in the area of epistemic beliefs and an online community of practice hosted by a firm. First, a four-factor structure was a plausible but somewhat flawed instrument for studying epistemic beliefs for design knowledge. Second,

the proposed model used in the study had different explanatory powers in relation to variability within self-reported likelihood of sharing contributions than within quality and quantity of actual contributions. Third, differences in contributions by gender were limited. Fourth, among the three variables which constituted levels of expertise, frequency of using the software best explained self-reported likelihood of contributions; levels of experience with the software best accounted for actual contributions. Fifth, belief about consistency of design knowledge had different relations with different measures of contributions. Finally, interaction between belief about consistency of design knowledge and levels of expertise explained contributions in the community of practice that was studied in this research.

Conclusion 1: A four-factor structure of epistemic beliefs about the nature of design knowledge and knowing was found but needed improvement.

In order to explore the nature of epistemic beliefs about design knowledge and ways of knowing, this study followed conventional scale construction procedures to validate the measurement of individuals' beliefs. First, Hofer's DEBQ was adapted to specifically address design problems and solutions. Second, a pilot study was conducted to confirm that survey questions were design-focused and understandable. Third, exploratory factor analysis was conducted in order to find a structure of the beliefs that fit the data set. Factor analyses indicated a four-factor model (Consistency of Design Knowledge, Source Authority of Design Knowledge, Attainability of Design Knowledge, and Contextual Factuality of Design Knowledge).

The four factors of epistemic beliefs about the nature of design knowledge and knowing are partially consistent with Hofer (2000). Almost all items in the first two factors, Consistency and Source Authority of Design Knowledge, were loaded on certain knowledge and source of knowledge: authority in Hofer's study. The only exception was Item 8 in Source Authority of Design Knowledge, which was not loaded on any of the factors from Hofer's study.

The Attainability of Design Knowledge factor is similar to attainability of truth in Hofer's study and Wood and Kardash (2002). Their factors focused on the attainment of objective truth. However, the factor in the present study is concerned specifically with design knowledge. Noticeably, all three items in this factor were not loaded on attainment of truth in Hofer's study, which may be one of the reasons that this factor had the lowest Cronbach alpha.

Regarding Contextual Factuality of Design Knowledge, both items were loaded on justification for knowing: personal in Hofer's study. Contextual Factuality here is to some extent more specific than the original factor that concluded in Hofer's study. Justification in her study was comprised of a view of justification that values both firsthand experience and the contextual characteristic of knowledge. However, the factor in this current study is only concerned with the contextual characteristics of design knowledge. The difference is conceivably due to the different age groups between the respondents in this study and in Hofer's study. Hofer contended that college students might be less capable of interpreting the meaning of some items that addressed sophisticated aspects of the justification for knowing. The issue of different capabilities of interpreting beliefs was also addressed in Schommer-Aikins (2002).

The Cronbach alpha for these four factors ranged from .467 to .692. Even though a reliability of .70 or higher is desirable in quantitative research, the lower Cronbach alpha obtained in this current study is not surprising. Cronbach alphas of .50 are common in studies of epistemic beliefs. For example, the Cronbach alpha from Schommer's (1993) four-factor structure ranged from .51 to .78. Jehng, Johnson, and Anderson (1993) obtained a Cronbach alpha of .42 to .59 from their five-factor structure. Finally, the five-factor structure used by Wood and Kardash (2002) resulted in a Cronbach alpha of .54 to .74. The instruments developed

in these three studies have been widely used in the field (see Chapter 2 for an in-depth discussion).

The reliability of the four factors from the current study was close to what was found by Hofer (2000). Specifically, Consistency of Design Knowledge had a satisfactory Cronbach alpha, but was slightly lower than the factor from Hofer (.69 versus .74, respectively). Source Authority of Design Knowledge in this study also had a higher Cronbach alpha (.61 versus .51).

Attainability and Contextual Factuality of Design Knowledge were less satisfactory and lower than those factors from Hofer's study. Since the items in Attainability of Design Knowledge were different from what was found in Hofer, the lower reliability may indicate problems associated with adapting the original items to the design-focused items. Future research is needed to further investigate this issue. Moreover, Cronbach alpha highly depends on the length of the test (Schmitt, 1996), which may have partially contributed to the low reliability for Contextual Factuality. For example, if eight items are included in the factor and the correlation between items in Contextual Factuality is the same, the Cronbach alpha is .811. This example shows how the number of questions included in the analysis can greatly impact the Cronbach alpha.

Though the reliability from this study is close to those reported in similar studies found in the literature, the reliability of the factors is still lower than desired, which indicates a need for further development of the instruments used to investigate epistemic beliefs. Until those instruments can be developed, factors with low reliability should be used cautiously. Therefore, the current study took a more conservative route to understanding the relation between individuals' epistemic beliefs and knowledge contributions within the online community of practice by excluding those factors with low internal consistency (i.e., Attainability and Contextual Factuality of Design Knowledge) from the regression analyses.

In summary, a four-factor structure about design-focused epistemic beliefs was found in this current research. These findings suggested that epistemic beliefs could be used to understand an adult's learning process. From a theoretical point of view, domain-specific beliefs are more appropriate for adults. Shommer-Aikins (2002) postulated, "As children are exposed to ideas from family, peers, culture, and formal education, their personal epistemology may become more domain specific...it is likely that as learners progress in their development they will acquire both domain-specific and domain-general epistemological beliefs" (p. 112). Based on the empirical findings from this study, a questionnaire developed for the purpose of understanding college students' epistemic beliefs could be used to explore adults' beliefs. However, Attainability of Design Knowledge requires further investigation about the construct validity.

Conclusion 2: The proposed model had different explanatory power for different measures of contributions.

The proposed model provided a satisfactory explanation for the variability of the quantity (27.7 percent of the variability) and quality (29.4 percent of the variability) of actual contributions. However, the model explained less of the variability in self-reported likelihood of sharing contributions, explaining 16 percent of the variability in low-level contributions, 14.3 percent in mid-level contributions, and 12 percent in high-level contributions.

Different types of contributions were found to be associated with different significant explanatory variables. For example, belief in Consistency was the main effect for the self-reported likelihood of sharing mid-level and high-level contributions as well as for the quality of contributions, but it interacted with levels of expertise for self-reported likelihood of sharing low-level contributions and quantity of actual contributions. This finding shows that different characteristics existed not only between participants' self-reported likelihood contributions and actual contributions, but also within different measures of self-reported likelihood of

contributions and within actual contributions. These five measures are different in nature. The distinctive characteristics between quality and quantity of contributions have also been addressed by the study from Peddibhotla and Subramani (2007). They found that quality and quantity of contributions are driven by different types of motivation. Constant, Sproull, and Kiesler (1996) also concluded a negative relationship between number of replies and reply usefulness. These contributions need to be understood differently, and perhaps require different community policies and incentives to encourage members' participation.

Conclusion 3: Gender had a relationship to three levels of self-reported likelihood of sharing contributions but did not have a relationship to their actual contributions.

Findings from this study revealed that gender had a significant relationship to the self-reported likelihood of sharing low-level contributions, which assessed how likely an individual was to post a comment when he had a question or needed clarification. According to the regression analysis of the low-level contributions, males reported that they were less likely to ask questions in the online community of practice, and females reported that they were more likely to post their questions or to request clarification. This may be explained in part by men having a higher degree of concern for ego and perceiving a higher degree of self-risk when seeking feedback (Miller & Karakowsky, 2005). Meanwhile, female respondents in this study could tend to apply more direct methods to obtain help, since the studied community was male-dominated. According to Holder (1996), when females entered a male-dominated job setting, they tended to apply more direct methods because they felt it was unlikely that they would receive complete and accurate information if they sought information indirectly.

Gender was also a significant explanatory variable for likelihood of sharing mid-level and high-level contributions. Though males reported they were less likely than females to actively ask questions or request clarification, they reported they were more likely than females to

contribute to the design community when they found typos, disagreed with the information published on a help page, found relevant tips or information from other sources, had ideas of how to enhance content, or wanted to share relevant instructions they had created. Similar results were found in Siemsen, Roth, and Balasubramanian's study (2008) of IT professionals, aircraft technicians, and line works, which indicated that males were more likely than females to share their knowledge.

Noticeably, even though males reported that they were more likely to contribute their knowledge, gender was not a significant variable for actual contributions. In other words, there was only a gender difference in self-reported likelihood of contributing to the community but not a gender difference in actual contributions. This indicates that while males might hold more positive attitudes toward sharing their knowledge than females, these attitudes do not seem to affect actual behaviors. Since on-the-job, informal training happens frequently and online communities of practice have become an important learning environment in which to receive that training, it is encouraging to learn that gender and age do not explain individuals' actual contributions.

Conclusion 4: Frequency of using the software explained self-reported likelihood of sharing contributions and levels of experience with the software explained actual contributions.

In order to comprehensively measure levels of expertise, this study included three criteria to evaluate expertise: levels of experience with the software, years of experience in the profession, and frequency of using the software. The first criterion examined how skillful an individual was in using the design software. Years of experience in the profession considered both expertise in the profession and expertise with the tool. In some cases, designers may have advanced knowledge about design but limited knowledge about how to use the technology to

present their design work and vice versa. The two types of knowledge may not have developed synchronously. Finally, since not all designers work full time in the field, the third criterion was a proxy to understand whether the respondents were amateurs or professionals. As expected, these three variables had moderate positive relationships.

Not surprisingly, individuals with more years of experience in the profession reported that they were less likely to post a comment, if they had a question or needed clarification. A possible explanation may be that these individuals might have been more ego-defensive and tended not to ask questions in order to try to maintain their own perception of their own expertise. It might also be that people who have been in a profession longer have more resources to choose from, such as peers they might call with a question instead of having to rely on an online community of practice.

Regarding frequency of using the software, all measures of self-reported likelihood of contributions were related to this variable. The more frequently individuals used the software, they reported that the more likely they were to ask questions, share errors they found on a help page, or share tips or instructions. A possible explanation is that those who used the software more often might have been more familiar with the community content and culture and might have felt more comfortable contributing to the studied community of practice.

Additionally, the regression findings indicated that individuals' software skills explained their quality and quantity of actual contributions. In general, the more experience they had with the software, the higher the quality and quantity of the contributions they provided. This is consistent with the finding in Constant et al. (1996) that people had more positive attitudes toward sharing when they felt that they were experts in the subject matter of a question. However,

the relationships depended on their belief in Consistency of Design Knowledge and years of experience in design. Further discussion is presented in the next section.

Interestingly, frequency of using the software only explained self-reported likelihood of providing contributions, and level of experience with the software only explained actual contributions. This may imply that individuals may have had different considerations when they were asked about their attitude toward contributions than when they actually contributed their knowledge. This finding is important, since most previous studies have only researched individuals' self-reported contributions but the results have often been assumed by the researchers to be generalizable to individuals' actual contributions. However, since the findings in this study demonstrate that individual's self-reported likelihood of sharing contributions might not precisely reflect individuals' actual contribution behaviors, researchers in the field need to be more cautious about generalizing findings from the self-reported contributions.

Conclusion 5: Belief about Consistency of Design Knowledge had different relations with different measures of contributions.

In order to only use reliable factors to understand individuals' contributions in an online community of practice hosted by a firm, two factors were removed from the regression analyses, Attainability and Contextual Factuality of Design Knowledge. This decision was believed to provide more trustworthy findings about individuals' contributions. Of the two reliable factors of epistemic beliefs, Source Authority of Design Knowledge was not significant for all measures of contributions. However, Consistency of Design Knowledge was related to all measures of contributions.

The belief about Consistency of Design Knowledge had a direct relation—or main effect—with the self-reported likelihood of sharing mid-level and high-level contributions and quality of their actual contributions. Consistency of Design Knowledge also interacted with other

expertise variables for likelihood of sharing low-level contributions and quantity of contributions. When individuals believed more in consistency of design knowledge, they were less likely to post a comment about typos, disagreement with the content in the community, relevant tips from other sources, or relevant instructions they had created. One possible explanation is that people might have hesitated to share their knowledge in the studied community when they believed that there was correct and incorrect knowledge and design knowledge was consistent (Ardichvili, Page, & Wentling, 2003). Further discussions about belief in Consistency of Design Knowledge and its interaction with other variables for levels of expertise are presented in the following section.

Conclusion 6: Interaction between belief about Consistency of Design Knowledge and levels of expertise accounted for likelihood of sharing low-level contributions and actual contributions.

The interactions between belief about Consistency of Design Knowledge and levels of expertise correlated with likelihood of sharing low-level contributions and quality and quantity of actual contributions. Belief in Consistency of Design Knowledge had interactions with levels of experience and with frequency of using the software in relation to likelihood of sharing low-level contributions. In terms of level of experience with the software, more experienced participants at an above-average level of belief were more likely to post comments when they had questions or needed clarification. On the contrary, more experienced participants at a below-average level of belief were less likely to post comments under the same circumstance. Findings in previous studies indicated that the more experience individuals had, the more positive their attitudes toward sharing were (Constant et al., 1996). However, this current research found that this relationship only applied to individuals who had a strong belief in consistency of design knowledge. Even though this finding was unexpected, it is reasonable to believe that those

individuals who perceived themselves as experts and had a strong belief in Consistency of Design Knowledge might have had more confidence about what they knew and, therefore, might not have hesitated to post a comment in the studied community when they had a question or needed clarification. This might also explain why those experts with more belief in inconsistency of design knowledge were less likely to post comments, since they would have considered that there was no single correct answer and that what they knew might only be valid in certain contexts.

As expected, those who had less experience using the software and used the software often (daily or weekly) were more likely to share their questions and confusion with the community, when they had a weak belief in consistency of design knowledge. However, this study found that expert users with a strong belief in consistency of design knowledge were more likely to share their questions and confusion than those with a weak belief, regardless of their frequency of using the software. According to existing studies, people with belief in consistent, certain, and simple knowledge preferred finding a single answer (Bendixen & Hartley, 2003; Hofer, 2004; Schommer, 1998). Additionally, these respondents who indicated that they were experts might have more confidence about what they knew. As a result, when they found confusing content, these experts with a strong belief in consistency of design knowledge were more likely to share questions and confusion.

Interestingly, if the beginners did not use the software often (2 to 3 times per month or monthly), what they believed about design knowledge only had minimum impact. Instead, the frequency of using the software became more important. The less frequently they used the software, the more likely they were to ask questions and request clarification in the studied community. This might have been because these individuals held a more traditional view of the

firm-hosted community. When they used the software less frequently, these beginners might be less knowledgeable about the community and think that the company owns (Lee & Cole, 2003) and is responsible for answering questions about its content. In this vein, posting questions on the community of practice may have been similar to getting support from the company for these beginners, so they might have believed that it was easier to obtain answers and tended to post their questions.

In terms of quality of actual contributions, belief in Consistency of Design Knowledge and levels of experience with the software was the only significant interaction. As expected, for those who believed in consistency of design knowledge at and above the mean level, experts posted higher quality contributions than advanced users, intermediates, and beginners. The differences in quality of contributions between different levels of expertise were more noticeable when they had consistent design knowledge scores at the above-average level. For those with scores at and above the mean level, the more experts and advanced users believed in consistency of design knowledge, the higher the quality of the contributions they posted, while the more beginners and intermediates believed in consistent knowledge, the lower the quality of contributions they shared. These findings are logical, since experts might have had more confidence than novices about what they knew as knowledge, and this effect might have been amplified when individuals had a stronger belief in Consistency of Design Knowledge.

Interestingly, for those individuals who had Consistency of Design Knowledge scores at below the mean level, novices provided higher quality contributions than experienced users. This result was unexpected. Findings in research on expertise—that novices usually focused on specific technical features (Calabrese & Marucci, 2006) and that they tended to apply trial-and-error processes (Ahmed, Wallace, & Blessing, 2003)—provided a possible explanation for this

unexpected result. In comments that novices with a weak belief posted in the community, they seemed more likely than users with more experience to discover problems in community content, especially content with step-by-step instructions. They would often refer to a particular step where they found a problem. Individuals with more belief in inconsistency of design knowledge were less likely to be worried about the accuracy of their postings. As a result, they would be more likely to share what they found in the community and to point out important issues that experts might overlook. Accordingly, they contributed higher quality contributions.

With respect to the quantity of contributions, belief in Consistency of Design Knowledge was not a significant explanatory variable; however, its interactions with levels of expertise and with years of experience in design were significant. First, when individuals had Consistency of Design Knowledge scores at an above-average level, their levels of expertise with the software and years of experience in design did not make any difference in the quantity of contributions. In contrast, when they had consistency of design knowledge scores at an average level and a below-average level, as expected, experts usually shared more contributions than novices. The differences among different levels of expertise in quantity of contributions were more noticeable when they had a weak belief in Consistency of Design Knowledge.

When experts believed more in inconsistency of design knowledge, they contributed more. Many of their posted contributions in the community were related to providing more context about their previous messages and to expanding their ideas. This may be due to the fact that experts' comments might be more complex, and their belief in inconsistency of design knowledge might drive them to identify the context of their previous posts. This results in a higher quantity of contributions from experts. However, the differences in quantity of contributions for different levels of belief in Consistency of Design Knowledge became smaller

when these experts had worked in the field longer. This may imply that with more experience, these experts might have gotten better at explaining concepts, so they did not need to post several times to explain the same issue.

For beginners who had worked less than one year, those with a stronger belief in Consistency of Design Knowledge shared fewer contributions as compared to those with a weaker belief. This is a reasonable finding, since these beginners might have been afraid that the knowledge they shared was incorrect (Ardichvili, Page, & Wentling, 2003). On the contrary, for beginners who had worked more than three years in design, those with a stronger belief in Consistency of Design Knowledge unexpectedly shared more contributions. These individuals knew design content well but appeared to be less competent (i.e., beginners) in using the software to carry out their design ideas. Even though they might still have been afraid of sharing incorrect knowledge or asking basic questions, their extensive experience in design might provide them more confidence and mitigate the fear. This might be more applicable when these beginners were looking for answers, since the belief would drive them to find a single answer. As a result, these beginners posted more.

Recommendations

Based on the findings from this study, a number of recommendations for future research and practice are provided below.

Implications for theory and instrument development.

The present research establishes that domain-focused epistemic beliefs are an important element in understanding individuals' contributions to an online community of practice. In addition, the study advances prior research on the beliefs by using the instrument developed for

college students in traditional school settings and modifying it for adults in informal training environments. An issue to consider in extending the theory to adults is the reliability and validity of the instrument. There are two advantages to using Hofer's DEBQ (2000). First, it is easy to adapt to a domain-focused questionnaire. Second, the questionnaire is parsimonious which can reduce the effects of fatigue that may arise from answering a long list of traditional epistemic beliefs questions. However, the current findings also reveal several possible ways to improve the instrument.

Even though the reliability from this current study is close to that in Hofer (2000) and is not particularly low compared to other related studies, future research on the improvement of instruments for epistemic beliefs is required. In this current research, only 14 of 27 items were used to identify the factors, which resulted in close to 50 percent of items being lost and the four-factor solution only explaining 34.7 percent of total variance. This is a serious issue across all epistemic belief instruments. Future research should focus on clarifying the construct and validating the instrument of epistemic beliefs, especially the factors of Attainability and Contextual Factuality of Design Knowledge. This process should include reexamining the theoretical rationale for different factors, developing items based on the well-defined factors, and using more conservative criteria to select items. Such a process might also help to create a more parsimonious instrument for measuring individual epistemic beliefs. A concise and reliable instrument of epistemic beliefs would help researchers better investigate the relation between epistemic beliefs and other variables in different contexts. It could help a study like this current study investigate the contributions in an online community of practice using multiple epistemic factors.

Implications for research.

A limitation of this current research was that not many participants had made actual contributions to the studied community. As Nielsen (2006) pointed out, in online communities, 90 percent of members are lurkers who never contribute, 9 percent of them contribute intermittently, and 1 percent of them contribute most of the content. In other words, this is a normal situation in an online community of practice, even when investigating high-traffic communities, such as the one in this study. Future research that utilizes the same method to review individuals' actual contributions for a longer period of time than the period in this study could gain additional insights and perhaps some novel findings that could add to the validity of findings in that study.

One interesting future research agenda that was beyond the scope of the current study would be to conduct a content analysis of contributions to understand the influence of epistemic beliefs. In this study, participants' comments were reviewed in order to understand interactions between epistemic belief and levels of expertise in relation to their actual contributions. However, a content analysis would have provided a more systematic and reliable way to target the content of those contributions. Though people contributing the same quality of comments may still have had different types of contributions, such analysis would have been particularly helpful in understanding the implications of quantity of contributions, since diverse content may be included in the notion of quantity of contributions. A more systematic understanding of the specific content contributed by different members may provide some insights for community managers about ways to solicit community moderators and organize community policies; as a result, they might be able to build more active and healthy communities of practice.

Content analysis could also be used to study how different epistemic beliefs might influence moderators' facilitation patterns. The patterns could be discovered by conducting content analysis of moderators' postings. Sinatra and Kardash (2004) found that teachers' epistemic beliefs may influence their teaching strategies. Hence, it is possible that moderators with certain types of epistemic beliefs would post more encouraging and perhaps more friendly responses. These moderators might be more likely to invite people to actively participate in a community, and they might also be the group that administrators would want to recruit. Findings from future research could inform community administrators about how to encourage interactions between newcomers and old-timers.

In addition, the online community of practice hosted by a firm is a special type of community. It may be hard for its members to separate the relation between the company and the community. Especially when the company is for-profit, people may hold higher expectations, which may result in different participation patterns. Their epistemic beliefs may also function differently in this type of community. Future research that considers group- and organizational-level factors (e.g., community culture, norms, or reward systems) to discuss an influence of epistemic beliefs on individuals' contributions to an online community of practice hosted by a firm is of interest. In the same vein, future research using the same model to explore different types of communities, such as an open-source community or a non-profit online community, and to take communities' characteristics and the group-level factors into account could gain additional insights.

Implications for practice.

Within the two measures of actual contributions, quality of contributions indicates how much value is added to the community by each contribution, while quantity indicates how active

the community is. Findings from this research showed that quality and quantity of actual contributions did not correlate with each other. Furthermore, the regression analyses indicated that the two measures needed different explanatory variables to understand the phenomenon. One disadvantage of the quantity of contributions is that it cannot indicate anything related to the content, other than the user's activity level. This limitation prompted more investigation into the user comments to attempt to better understand the content and find a reasonable interpretation of findings from the quantity of contributions. Different types of communities may apply different measures to track the status of the community. For instance, a cancer support community might care about how many comments they received per day. For an online community of practice hosted by a firm, like the studied community, quantity of contributions by itself might not bring much information. Two individuals could have the same number of contributions, but those contributions might be very different in nature. For example, one could ask five questions, and the other could share five useful links to tips and instructions. It might be more important for firms to track quality of contributions and number of each type of contributions. It would also be helpful if the firm could conduct content analyses of the contributions and track the number of each category of contribution. These measures could provide not only insights about the content, but also details about activity of each type and category of contribution.

Based on findings in the current research, a major implication for practice is that epistemic beliefs should be considered when designing a community. As discussed in Chapter 2, several studies have highlighted the effects of epistemic beliefs on individuals' learning performance (Jacobson & Spiro, 1995) and information-seeking behavior (Aleven et al., 2003; Hofer, 2004). Other studies have shown how beliefs influence how well people learn in different

types of learning environments (Windschitl & Andre, 1998) and with different types of learning facilitations (Demetriadis et al., 2008).

In order to encourage high-quality contributions, a design that supports beginners and intermediates with a belief in Inconsistency of Design Knowledge and a design that supports experts and intermediates with a belief in Consistency of Design Knowledge are suggested. For example, when beginners and intermediates visit an instructional webpage for a particular topic, it may be useful to see other related resources for the same topic or other related topics. The suggested design would allow these individuals to cross-reference related sources easily and help them find relevant instructions. They could then decide which content is useful. Since they might be more likely to read the content closely and find any discrepancies, they may be more inclined to provide feedback in the form of high quality contributions. Experts and advanced users might be more appreciative if they could obtain the desired content more directly and if less relevant content could be filtered out. Hence, a system that highlights suggested content might be more helpful for expert and advanced users. Since the design could help the experts find useful content easily, they may have an increased opportunity to take advantage of the content. If they see any inconsistent content based on their knowledge, experts may be more likely to have high quality contributions.

Increasing both visibility of and participation in a community among users is a major challenge. Similar to other online communities, the firm in this study has an enormous population of users, and the majority of them are not aware of the online community, limiting their ability to take advantage of community content and hindering the development of the community itself. Also, one observed limitation in current research is that only a small number of community users actually contribute to the community. As Iriberry and Leroy (2009) pointed

out, it is important to reach a high number of critical members within a short period of time in the growth stage of a community, as they are likely to contribute the majority of the content. In addition, based on the theory of communities of practice (Lave & Wenger, 1991), experts are the key to creating a healthy and vibrant community. Through interacting with experts, a sense of membership and a sense of belonging to the community can be gradually established, and novices can become more familiar with the practice and eventually become experts. This is the group that usually provides high-quality content to the community. If they could participate and contribute to the community on a regular basis, they could become the essence of the community and accordingly enhance the value of the community itself. Therefore, in order to increase participation among members and the quality of community content, one strategy the firm might employ is to reach out to experts based on their epistemic beliefs. By increasing the number of experts with belief in consistency of design knowledge, posted contributions might have higher quality and interaction between members could be enhanced. Finding critical members who can make high-quality contributions to a community is an important issue that all practitioners are investigating. The value of the community is determined by the participation of its critical members. This current research provides a method to identify these people, and the method is particularly helpful when the community is just getting started.

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Appendix A

Epistemic Beliefs Questionnaire

I. Personal Profile:

1) What is your gender?

- ☐ Male
- ☐ Female
- ☐ Prefer not to state

2) What year were you born? (Please enter the 4-digit birth year, e.g., 1950)

3) Which of the following descriptions best matches your level of experience with using [one of the software that developed by the firm]:

- ☐ Never Used: I have never used the product.
- ☐ Beginner: I know of a few features, only some of which I actually know how to use.
- ☐ Intermediate: I am familiar with enough features to get the job done but I still have a lot to learn.
- ☐ Advanced: I confidently use and understand many of the features and can troubleshoot common problems.
- ☐ Expert: I am highly skilled in most (or all) of the features and can troubleshoot most of the problems I encounter.

4) Approximately how long have you worked in the field of [one of the following fields: graphic design or Web design]?

- ☐ Less than 1 year
- ☐ More than 1 year but less than 3 years
- ☐ More than 3 years but less than 5 years
- ☐ More than 5 years but less than 7 years
- ☐ More than 7 years but less than 9 years
- ☐ More than 9 years

5) How often do you use [one of the following programs: Dreamweaver, Fireworks, Flash, Illustrator, InDesign, or Photoshop]:

- ☐ Daily
- ☐ Weekly
- ☐ 2 to 3 times per month
- ☐ Monthly
- ☐ Less than once per month

II. Your Beliefs about the Nature of Design

Instructions: Please answer the following questions as best you can. There is no right or wrong answer for the following statements. We want to know how much you agree or disagree with each of these statements.

When you are answering these questions, please give us your beliefs about **The Field of [one of the following fields: Graphic Design, Interactive Design, or Web Design]**

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Theories are unchanging in the field of design.	1-----	2-----	3-----	4-----	5
In the field of design, most problems have only one right solution.	1-----	2-----	3-----	4-----	5
Sometimes you just have to accept design solutions from the experienced designers, even if you don't understand them.	1-----	2-----	3-----	4-----	5
What we accept as knowledge in design is based on objectivity.	1-----	2-----	3-----	4-----	5
All design theorists would probably come up with the same solutions to problems.	1-----	2-----	3-----	4-----	5
The most important work of design is coming up with original ideas.	1-----	2-----	3-----	4-----	5
If you read something in a book for design, you can be sure it is true.	1-----	2-----	3-----	4-----	5
A theory in design is accepted as correct if experts reach consensus.	1-----	2-----	3-----	4-----	5
Most of what is true in the field of design is already known.	1-----	2-----	3-----	4-----	5
Real-life design problems are really complex.	1-----	2-----	3-----	4-----	5
In the field of design, it is good to question ideas presented.	1-----	2-----	3-----	4-----	5
Correct solutions in the field of design are	1-----	2-----	3-----	4-----	5

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
more a matter of opinion than fact.					
If design theorists try hard enough, they can find the design solutions to almost anything.	1-----	2-----	3-----	4-----	5
The most important part of being an experienced designer is accumulating a lot of knowledge about different design problems.	1-----	2-----	3-----	4-----	5
I know the design solutions to problems because I have figured them out for myself.	1-----	2-----	3-----	4-----	5
One expert's opinion in the field of design is as good as another's.	1-----	2-----	3-----	4-----	5
Experienced designers can ultimately get to the truth about design problems.	1-----	2-----	3-----	4-----	5
Principles in the field of design are unchanging.	1-----	2-----	3-----	4-----	5
Principles in design can be applied in any situation.	1-----	2-----	3-----	4-----	5
If my personal experience conflicts with ideas in a book, the book is probably right.	1-----	2-----	3-----	4-----	5
There is really no way to determine whether someone has the right solution in design.	1-----	2-----	3-----	4-----	5
Expertise in the field of design consists of seeing the interrelationships among ideas.	1-----	2-----	3-----	4-----	5
Solutions to problems in design change as experts gather more information.	1-----	2-----	3-----	4-----	5
All experts in design understand the field in the same way.	1-----	2-----	3-----	4-----	5
I am more likely to accept the ideas of someone with first-hand experience than the ideas of theorists in the field of design.	1-----	2-----	3-----	4-----	5

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I am most confident that I know something when I know what the experts think.	1-----	2-----	3-----	4-----	5
First-hand experience is the best way of knowing something in design.	1-----	2-----	3-----	4-----	5

III. How likely are you to **post a comment** on a piece of content on Adobe.com (e.g. troubleshooting documents or video tutorials)?

	Not at all Likely	Not very Likely	Somewhat Likely	Very Likely	Extremely Likely
How likely are you to post a comment, if you have a question about using the software?	1-----	2-----	3-----	4-----	5
How likely are you to post a comment, if you need clarification on a help page?	1-----	2-----	3-----	4-----	5
How likely are you to post a comment, if you find a typo on a help page?	1-----	2-----	3-----	4-----	5
How likely are you to post a comment, if you disagree with information published on a help page?	1-----	2-----	3-----	4-----	5
How likely are you to post a comment, if you find relevant tips or information from other sources?	1-----	2-----	3-----	4-----	5
How likely are you to post a comment, if you have an idea of how to enhance content on a help page?	1-----	2-----	3-----	4-----	5
How likely are you to post a comment, if you want to share relevant instructions, tips, or tutorials that you have created?	1-----	2-----	3-----	4-----	5

Thank you very much for participating! Please click “SUBMIT SURVEY” to finish.

Appendix B

Descriptive Statistics for Items of Epistemic Beliefs

Table B1

Means and Standard Deviations of Epistemic Beliefs Items

Item	<i>M</i>	<i>SD</i>	<i>n</i>
1: Theories are unchanging in the field of design	2.22	1.073	283
2: In the field of design, most problems have only one right solution	1.51	.711	283
3: Sometimes you just have to accept design solutions from the experienced designers, even if you don't understand them	2.61	1.056	284
4: What we accept as knowledge in design is based on objectivity	2.82	.997	283
5: All design theorists would probably come up with the same solutions to problems	1.77	.780	283
6: The most important work of design is coming up with original ideas	2.97	1.180	283
7: If you read something in a book for design, you can be sure it is true	1.90	.833	284
8: A theory in design is accepted as correct if experts reach consensus	2.92	.957	284
9: Most of what is true in the field of design is already known	2.34	1.026	282
10: Real-life design problems are really complex	3.21	.968	284
11: In the field of design, it is good to question ideas presented	4.18	.711	283
12: Correct solutions in the field of design are more a matter of opinion than fact	3.35	.997	283
13: If design theorists try hard enough, they can find the design solutions to almost anything	3.73	.925	283
14: The most important part of being an experienced designer in design is accumulating a lot of knowledge about different design problems	3.70	.936	283
15: I know the design solutions to problems because I have figured them out for myself	3.16	.911	283
16: One experts opinion in the field of design is as good as anothers	2.60	.997	283

(continued)

Table B1 (continued)

Item	<i>M</i>	<i>SD</i>	<i>n</i>
17: Experienced designers can ultimately get to the truth about design problems	3.48	.855	284
18: Principles in the field of design are unchanging	2.33	1.062	284
19: Principles in design can be applied in any situation	3.18	1.015	282
20: If my personal experience conflicts with ideas in a book, the book is probably right	2.24	.783	284
21: There is really no way to determine whether someone has the right solution in design	2.79	1.001	284
22: Expertise in the field of design consists of seeing the interrelationships among ideas	3.90	.753	282
23: Solutions to problems in design change as experts gather more information	3.95	.668	284
24: All experts in design understand the field in the same way	1.83	.724	284
25: I am more likely to accept the ideas of someone with first-hand experience than the ideas of theorists in the field of design	3.78	.876	284
26: I am most confident that I know something when I know what the experts think	3.03	.903	284
27: First-hand experience is the best way of knowing something in design	3.96	.803	284